CONVERGENCE OF TRADITIONAL TELEPHONY, ENHANCED TELECOMMUNICATIONS, PRIVATE DATA NETWORKING, AND THE INTERNET INTO HYPERCOMMUNICATIONS: IMPLICATIONS OF THE NEW ECONOMICS OF THE NETWORK FOR FLORIDA AGRIBUSINESSES

By

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KEY TO ABBREVIATIONS AND ACRONYMS

1G	1st Generation wireless (analog system)
2B1Q	2-Binary 1-Quaternary (modulation scheme)
2G	Second Generation (wireless)
3G	Third generation (wireless)
4G	Fourth generation (wireless)
10BASE-T	10MHz Twisted Pair (4-Wire UTP)
10BASE-5	10MHz "Thick Ethernet" (thick coaxial cable)
10BASE-2	10MHz "Thin Ethernet" (thin coaxial cable)
16QAM	16-level Quadrature Amplitude Modulation
8ZBS	
64-CAP	64-point Carrierless Amplitude/Phase (modulation)
64QAM	64-symbol Quadrature Amplitude Modulation
100BASE-FX	100MHz Fiber Optic
100BASE-T4	100MHz Twisted Pair (4-pair UTP CAT-3)
100BASE-TX	100MHz Twisted Pair (2-pair UTP CAT-5, category five twisted-pair copper)

a	atto (10^{-18}), quintillionth
A	Ampere (electrical current)
A2LA	American Association for Laboratory Accreditation
AAL	ATM-Adaption Layer
AAV	Alternative Access Vendors (FPSC)
ABR	Available Bit Rate (ATM)
AC	Alternating Current
AC/DC	Alternating Current - Direct Current
ACD	Automatic Call Distribution
A/D	Analog to Digital
ADC	Analog source to Digital signal Conversion
ADSL	Asymmetric Digital Subscriber Line
AIN	Advanced Intelligent Network
AIN	Average Incremental Costs
ALE	Access Line Equivalent (translation of enhanced telephone trunks into traditional access lines)
ALEC	Alternative Local Exchange Carrier (FPSC term for CLEC)
AM	Amplitude Modulation
AMI	Alternate Mark Inversion (carrier technology)
AMPS	Advanced Mobile Phone Service
AMS	Agricultural Marketing Service (USDA)
ANI	Automatic Number Identification
ANSI	American National Standards Institute
AOL	America OnLine
API	Application Program Interfaces

ARPA	Advanced Research Projects Agency
ASCII	American Standard Code for Information Interchange
ATM	Asynchronous Transfer Mode
AUI	Access Unit Interface
AWG	American Wire Gauge
b	bit
B	Byte
B_c	Committed Burst
B_e	Excess Burst
B2B	Business-to-Business
B8ZS	Binary 8(eight) Zero Suppression
BASIC	Beginner's All-purpose Symbolic Instruction Code
BEA	Basic Economic Areas (FCC license area)
BEA	Bureau of Economic Analysis
BER	Bit-Error Rate
BETRS	Basic Exchange Telephone Radio Service
B-ISDN	Broadband ISDN (ATM protocol)
BIT	Binary digIT
BLS	Bureau of Labor Statistics
BOD	bandwidth On-Demand
bps	bits per second
BPSK	Binary Phase-Shift Keying
BRI	Basic Rate Interface (ISDN)
BSOD	Blue Screen of Death (result from crashes of Windows 95 or later)
BTA	Basic Trading Area (FCC, licensing area)
BW	BandWidth
c	centi (10^{-2}), hundredth
C	Coulomb (electrical charge)
C&I	Long-run fixed economic cost of CPE an installation (conceptual model)
C band	satellite band that uses 3.4-4.8 GHz for downlink, 5.85-7.1 GHz for uplink
C/N	Carrier to Noise (ratio)
CAD	Computer Aided Design
CALLS	Coalition for Affordable Local and Long-distance Service)
CAP	Carrierless Amplitude and Phase (modulation)
CATV	CAble TeleVision
CATV	Community Antenna TeleVision
CB	Citizen's Band (radio)
.cc	Top level domain name for Cocos (Keeling) Islands
CC	Call Center
CCB	Common Carrier Bureau (FCC)
CCIC	Committee on Computing, Information, and Communications
CCIR	Comité Consultatif International des Radiocommunications
CCITT	Comité Consultatif International Téléphonique et Télégraphique
CCITT	Consultative Committee on International Telephone and Telegraph
CCL	Common Carrier Line
CCLC	Common Carrier Line Charge (regulatory charge replaced by PICC)
CCS	Common Channel Signaling
CD	Compact Disk
CDP	Census Designated Place (un-incorporated area grouped by Census Bureau)

CDPD	Cellular Digital Packet Data
CDMA	Code-Division Multiple-Access
CDT	Call Detail Record (telemanagement)
CDSL	Consumer Digital Subscriber Line (Rockwell)
CDPD	Cellular Digital Packet Data
CGI	Common Gateway Interface
CID	Caller ID
CIDCW	Calling Identity Delivery on Call Waiting
CIO	Chief Information Officer
CIR	Committed Information Rate
CLEC	Competitive Local-Exchange Carrier
CLLI	Common Language Location Identifier
CMA	Cellular Market Area (FCC)
CMI	Code Mark Inversion
CMRS	(digital cellular)
CND	Calling Number Delivery
CNR	Carrier-to-Noise Ratio
CO	Central Office
CODEC	Coder/Decoder
COLR	Carrier of Last Resort
.com	Top level domain name for commercial businesses
COMPANDER	COMpressor-ExPANDER
COMSAT	COMmunications SATellite corporation (U.S.)
CPE	Customer Premise Equipment
CPI	Consumer Price Index
CPU	Central Processing Unit
CRC	Cyclical Redundancy Checksum
CRT	Cathode Ray Tube
CSA	Carrier Service Area
CSD	Circuit-Switched Data
CSN	Circuit-Switched Network
CSU	Channel Service Unit
CSU	Customer Service Unit
CT	Computer Telephony
CTC	Community Technology Centers (U.S. Department of Education)
CTI	Computer Telephony Integration
CTO	Chief Technical Officer
CVP	Cellular Voice Paging
CW	Continuous Wave
CZ	Coverage Zone

d	deci (10^{-1}), tenth
D/A	Digital-to-Analog
DAC	Digital source to Analog signal Conversion
DACS	Department of Agriculture and Consumer Service (Florida)
D-AMPS	Digital Advanced Mobile cellular-Phone Service
dB	deciBel
DC	Direct Current
DCE	Data Communications Equipment
DCE	Data Circuit terminating Equipment
DCS	Digital Cross-connect Systems

DBS	Direct Broadcast Systems
DDS	Digital Data Service (dedicated circuit service)
DEMUX	Demultiplexer
DEMS	Digital Electronic Message Service
DHCP	Dynamic Host Configuration Protocol
DHTML	Dynamic HTML
DID	Direct Inward Dial (telephony)
DLC	Data Link Control (OSI layer)
DLC	Digital Loop Carrier (Access level)
DMT	Discrete Multi-Tone (modulation)
DNS	Domain Name System/Service
DOCSIS	Data-Over-Cable-Service Interface Specification
DOS	Disk Operating System
DPSK	Differential Phase Shift Keying
DQPSK	Differential Quadrature Phase-Shift Keying
DS	Digital Signal (DS-0=64 kbps, DS-1=1.544 Mbps, DS-3, etc.)
DS-CDMA	Direct-Sequence Code-Division Multiple-Access
DSL	Digital Subscriber Line
DSLAM	Digital-Subscriber Line Access Multiplexor
DSP	Digital Signal Processing
DSU	Data Service Unit
DTE	Data Terminal Equipment
DTMF	Dual Tone Multiple Frequency (Touch Tone™)
DTS	Digital Termination Systems (DEMS)
DTV	Digital TeleVision
DWDM	Dense Wave Division Multiplexing
DWMT	Discrete Wavelet Multi Tone (Aware, Inc. *de facto* DMT modulation standard)

E	Exa (10^{18}), quintillion
EAEA	Equal Access Exchange Area
EAS	Extended Area Service (telephony)
EC	Electric Cooperative
ECE	Electrical and Computer Engineering
ECS	Electronic Cross-Connect System
ECPR	Efficient Component Pricing Rule
ECSA	Exchange Carrier Standards Association
ECTF	Enterprise Computer Telephony Forum
EDI	Electronic Data Interchange
.edu	Top level domain name for two or four-year institutions of higher learning
EHF	Extremely High Frequency (3-39 GHz)
EIA	Electronics Industry Alliance
EIA	Electronic Industries Association
ELF	(Extremely Low Frequency) (30 Hz-300 Hz)
e-mail	Electronic mail
EMI	ElectroMagnetic Interference
ENDEC	Encoder-Decoder
ENIAC	Electronic Numerical Integrator And Computer (1946)
ERS	Economic Research Service (USDA)
E-SMR	Enhanced Specialized Mobile Radio
ESF	Extended Super Frame
ESSX®	BellSouth Centrex service (virtual PBX)

ETC (Exempt Telecommunications Company)

f	femto ($10^{\wedge -15}$), quadrillionth
F	Farad (capacitance)
FAQ	Frequently Asked Questions
FAX	Facsimile
FB	Facilities-Based
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FDM	Frequency Division Multiplexing
FDDI	Fiber Distributed Data Interface
FDMA	Frequency-Division Multiple-Access
FEXT	Far-End Cross Talk
FFSK	Four-level Frequency-Shift Keying
FITL	Fiber In The Loop
FM	Frequency Modulation
FO	Fiber Optic
FPSC	Florida Public Service Commission
FRAD	Frame Relay Access Device
FRC	Federal radio Commission (predecessor of FCC)
FSK	Frequency-Shift Keying
FSS	Fixed Satellite Service
FTP	File Transfer Protocol
FTTB	Fiber-To-The-Building
FTTC	Fiber-To-The-Curb
FTTCab	Fiber-To-The-Cabinet
FTTH	Fiber To The Home
FTTN	Fiber To The Neighborhood
FX	Foreign Exchange (telephony)

G	Giga (10^9), billion
GE	Gigabit Ethernet
GEO	GEOsynchronous orbit (satellites)
GIS	Geographic Information System
GPR	General Packet Radio
GPRS	General Packet Radio Service (GSM)
GPS	Global Positioning System/Satellite
GSM	Global System for Mobile communications, Groupe Speciale Mobile (digital mobile telephones)
GSO	GEOstationary orbit (satellites)
GUI	Graphical User Interface
GWCS	General Wireless Communications Service

h	hecto (10^2) ,hundred
H	Henry (inductance)
H	High (level)
H.320	umbrella standard for video transmission
HCL	High Cost Loop (Universal Service mechanism)
HCPM	Hybrid Proxy Cost Model (FCC)
HD	High Density
HDSL	High-bit-rate Digital Subscriber Line

HDSL2	High bit-rate Digital Subscriber Line version 2 (high efficiency line code)
HDTV	High-Definition TeleVision
HF	High Frequency
HFC	Hybrid Fiber/Coax (technology)
HQ	Head Quarters
HRI	Hospitals, Restaurants, and Institutional (food market)
HTML	HyperText Markup Language
HTTP	HyperText Transport/Transfer Protocol
Hz	Hertz

iDEN	Trademarked SMR technology (integrated Dispatch Enhanced Network)
IAB	Internet Architecture Board
IAP	Intranet Application Platform
IAS	Interstate Access Support (FCC Universal Service mechanism)
IBM	International Business Machines
ICC	International Conference on Communications
ICC	Interstate Commerce Commission
ICCE	International Conference on Consumer Electronics
iDEN	Integrated Dispatch-Enhanced Network
IDSL	Digital Subscriber Line with ISDN overlay (ANSI standard)
IEC	International Electrotechnical Committee/Commission
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IF	Intermediate Frequency
IFAS	Institute of Food and Agricultural Sciences (University of Florida)
IFRB	International Frequency Review Board, predecessor to CCITT
IIS	Internet Information Server (Microsoft)
ILEC	Incumbent Local Exchange Carrier
IMAP	Internet Message Access Protocol (e-mail)
IMTS	Improved Mobile Telephone Service (analog cellular)
INMARSAT	INternational MARitime SATellite organization
.int	Top-level domain name for international organizations
INTELSAT	INternational TELecommunications SATellite organization
I/O	Input/Output
IO	Industrial Organization
IO	Input-Output
IP	Internet Protocol
IPng	Internet Protocol next generation (version 6)
IPO	Initial Public Offering
IPX	Internet packet Exchange (Novell)
IR	Infrared
IR	Infrared Radiation
IRC	Internet Relay Chat
IRQ	Interrupt ReQuest
ISDN-BRI	Integrated Services Digital Network (Basic Rate Interface)
ISDN-PRI	Integrated Services Digital Network (Primary Rate Interface)
ISM	Industrial, Scientific and Medical (frequency bands)
ISO	International Standards Organization
ISP	Internet-Service Provider
IT	Information Technologies
IT	Internet Technologies

ITS	Institute for Telecommunications Sciences, NTIA
ITU	International Telecommunications Union
IVR	Interactive Voice Response
IXC	Inter-Exchange Carrier (long-distance carrier)
J	Joule (energy)
JND	Just Noticeable Difference
JPEG	Joint Photographic Experts Group (standard)
JPEG	Joint Picture Expert Group
k	kilo (10^3), thousand
ka band	new satellite band that uses 19.7-20.2 GHz (downlink) and 28.35-28.6 GHz (uplink)
KB or kB	kilobyte
kb	kilobit
ku band	satellite band that uses 14-14.5 GHz (uplink) and 10.7-12.2 (downlink)
LAN	Local Area Network
LASER	Light Amplification by Stimulated Emission of Radiation
LATA	Local Access and Transport Area
LCI	Line-Conducted Interference
LD	Long-Distance (telephony)
LDAP	Lightweight Delivery Access Protocol (portable e-mail and Internet settings)
LEC	Local Exchange Carrier
LEO	Low Earth Orbit (satellite)
LF	Low Frequency
LMDS	Local Microwave Distribution System
LMDS	Local Multipoint Distribution System
LMRS	Land Mobile Radio Services
LNP	Local Number Portability (telephony)
LSS	Local Switching Support (Universal service mechanism)
LTS	Long-Term Support (Universal Service mechanism)
LR	Long Run
LRAC	Long Run Average Cost
m	meter (length)
m	milli (10^{-3}), thousandth
M	Mega (10^6), million
MB	Megabyte
Mb	Magabit
MAC	Media/Medium Access Control (layer)
MAC	MacIntosh or Apple Computer
MAN	Metropolitan Area Network
Mbone	Multicast backbone
MDF	Main Distribution Frame
MDS	Microwave Distribution Systems
MDSL	Multi-rate Digital Subscriber Line
MEO	Middle Earth Orbit (satellite)
MFJ	Modified Final Judgement (AT&T breakup)
.mil	Top level domain name for U.S. military
MIME	Multipurpose Internet Mail Extensions
MIS	Management Information Service

MLDA	Multi-Location Discount Aggregator (FPSC)
MMDS	Microwave Multipoint Distribution System
MMDS	Multichannel Multipoint Distribution Service
MPEG	Motion Picture Expert Group
MPP	Marginal Physical Product
MRTS	Marginal Rate of Technical Substitution
MSDSL	Multi-rate Symmetric Digital Subscriber Line
MSA	Metropolitan Statistical Area
MSS	Mobile Satellite Service
MTA	Major Trading Areas (FCC SMR licensing)
MTE	Multi Tenant Environment
MVIP	Multi-Vendor Integration Protocol

n	nano (10^9)
NA	Numerical Aperture
NAMPS	Narrowband Analog Mobile Phone Service
NAP	Network Access Point (Internet backbone)
NARUC	National association of Regulatory Utility Commissions
NASS	National Agricultural Statistics Service (USDA)
NECA	National Exchange Carriers association
.net	Top level domain name for networks or businesses
NEXT	Near-End Crosstalk
NGO	Non-Governmental Organization
NGSO	Non-Geostationary Orbit (satellite)
NIC	Network Interface Card/Controller
NIPA	National Income Product Accounts
NIU	Network Interface Unit
NMS	Network Management Station (SNMP)
NNI	Network-Network Interface (ATM cell format)
NNTP	Network News Transport Protocol (USENET newsgroups)
NOC	Network Operations Center
NPA	Area code
NSF	National Science Foundation
NSP	Network Service Provider (Tier 1 Internet carrier)
NT	Network Termination
NT	Windows Operating System
NTIA	National Telecommunications and Information Agency
NTS	Non Traffic Sensitive
NXX	Telephone prefix

OC	Optical Carrier (OC-1=51.84 Mbps, OC-256=13.271 Gbps)
OCR	Optical Character Reader/Recognition
OEM	Original Equipment Manufacturer
OLE	Object Linking and Embedding
ONO	Overall Network Optimization
ONU	Optical Network Unit
OR	Operations Research
.org	Top level domain name for non-profit organizations (not restricted to non-profits)
OS	Operating System
OSI	Open System Interconnect (model, ISO)
OSI	Open Systems Interconnection

OSP	Online Service Provider (AOL, Prodigy)
p	pico (10^{-12})
PAHS	Probable Area of Highest Service (local exchange calling area)
PAM	Pulse Amplitude Modulation
PBX	Private Branch Exchange (Business telephone system)
PCI	Personal Communication Interface
PCIA	Personal Communications Industry Association
PCM	Pulse-Code Modulation
PC	Personal Computer
PCS	Personal Communications System
PDA	Personal Digital Assistant
PDM	Pulse Duration Modulation
PEM	Privacy Enhanced Mail (Internet)
PFM	Pulse-Frequency Modulation
PGP	Pretty Good Privacy (Internet encryption standard)
PICC	Presubscribed Inter-exchange Carrier Charge (regulatory-related fee)
PIN	Personal Identification Number
PLC	Power Line Communications
PM	Phase Modulation
PnP	Plug and Play
PON	Passive Optical Network
PON	Packet Over Network
POP	Point of Presence
POP3	Post Office Protocol version 3 (e-mail receipt)
POS	Packet Over SONET
POS	Point Of Sale
POSIR	Point Of Sales Internet Reporting
POTS	Plain Old Telephone Service (analog traditional telephony)
PPM	Pulse Position Modulation
PPP	Point-to-Point Protocol
PPTP	Point-to-Point Tunneling Protocol
PRI	Primary Rate Interface (IDSN with 24 channels)
PRM	Pulse Rate Modulation
PSK	Phase-Shift Keying
PSN	Packet Switched Network
PSNR	Peak Signal-to-Noise Ratio
PSTN	Public Switched Telephone System
PTO	Patent and Trademark Office
PVC	Permanent Virtual Circuit
Q	Quadrature (signal)
QA	Quality Assurance
QAM	Quadrature Amplitude Modulation (modulation)
QOS	Quality Of Service
QPSK	Quadrature Phase-Shift Keying
QPSK	Quaternary Phase-Shift Keying
RACC	Recurring ACCess charges (recurring costs in short run, conceptual model)
RADAR	Radio Detecting And Ranging
RADSL	Rate-Adaptive Digital Subscriber Line

RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
RAS	Remote-Access Server
RAV	Random Access Vehicle
RAV	Remote Access Vehicle (Wireline access level, ILEC)
RBOC	Regional Bell Operating Company (such as BellSouth)
REA	Rural Electrification Administration (predecessor of RUS)
RF	Radio Frequency
RFC	Receiving Flow Control
RFC	Request For Comments
RFP	Request For Proposal
RG-58 A/U	Thinnet, stranded wire core
RG-58/U	Thinnet, solid wire core
RG-62	ArcNet
RM	RealMedia
ROM	Read Only Memory
RTCP	Real-time Transfer Control Protocol
RTR	Recurring TRansport costs (short run, conceptual model)
RTS	Router Transport Service
RUS	Rural Utilities Service (successor to REA)

s	second (time)
S	Siemens (conductance)
S/N	Signal-to-Noise ratio
SAP	Service Access Point
SB	Switchless Rebiller (FPSC)
SBIR	Small Business Innovation Research (USDA program)
SCC	Specialized Common Carrier (predecessor of IXC)
SCI	Serial Communications Interface
SCI	Supply Chain Integrator
SCM	Supply Chain Management
SCSA™	Signal Computing System Architecture (Dialogic)
SDH	Synchronous Digital Hierarchy (SONET)
SDLC	Synchronous Data Link Control
SDSL	Single-pair Digital Subscriber Line
SDU	Service Data Unit
SHF	Super High Frequency (3-30GHz)
SI	International System of Units
SIP	Serial Interface Port
SIP	Simple Internet Protocol
SLA	Service Level Agreement
SLC	Schools and Libraries Corporation (Universal Service administering agency)
SLC	Subscriber Line Charge (regulatory-related fee)
SLIC	Subscriber-Line Interface Circuit
SLIP	Serial-Line Internet Protocol
SMR	Signal Modulation Rate
SMR	Specialized Mobile Radio
SMDS	Switched Multimegabit Data Service
SMDR	Station Message Detail Records (telemanagement)
SMTP	Simple Mail Transfer Protocol (e-mail sending)
SNA	Systems Network Architecture (IBM protocol)

SNMP	Simple Network Management Protocol (network management)
SNR	Signal-to-Noise Ratio
SOHO	Small Office Home Office
SONET	Synchronous Optical NETwork
SQL	Structured Query Language
SQPSK	Staggered Quadrature Phase-Shift Keying
SR	Short Run
SRAC	Short Run Average Cost
SRC	Sending Rate Control
SSB	Single Side Band
SS7	Signaling System 7
SSL	Secure Sockets Layer (e-commerce security)
SSMA	Spread Spectrum Multiple Access
STP	Shielded Twisted Pair (copper conduit)
STS	Shared Tenant Service (FPSC)
STS	Synchronous Transport Signal (fiber optics)
SVC	Switched Virtual Circuit
T	Tera (10^{12})
T-1	DS-1 T-carrier, 1.544 Mbps
TA	Terminal Adapter
TAPI	Telephony Applications Programming Interface (Microsoft)
TASS	Telecommunications Access System Surcharge (Fee funding deaf telephone relay service)
TCA	1996 Telecommunications Act
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDD	Time-Division Duplexing
TDM	Time-Division Multiplexing
TDMA	Time-Division Multiple-Access
TEL	Target Earnings Level
TIA	Telecommunications Industry Association
TLD	Top Level Domain (the .com or .net in Internet domain names)
.to	Top level domain name for Tonga
TOP	Technology Opportunity Program (U.S. Department of Commerce)
TS	Traffic Sensitive
TSAPI	Telephony Services Application Program Interface (Novell)
TTL	Time-To-Live
.tv	Top level domain name for Tuvalu
TV	TeleVision
U-NII	Unlicensed National Information Infrastructure (radio band)
UART	Universal Asynchronous Receiver/Transmitter
UBR	Unspecified Bit Rate
UDP	User Datagram Protocol
USDL	Universal Digital Subscriber Line (splitterless DSL)
UDWDM	Ultra-Dense Wavelength-Division Multiplexing
UHF	Ultra-High Frequency (300MHz-3GHz)
UL	Underwriter's Laboratories
UMTS	Universal Mobile Telecommunication System
UNE	Unbundled Network Element (telephony)

UNI	User Network Interface (ATM cell format)
URL	Uniform Resource Locator (web address)
.us	Top level domain name for sites in the United States (example: www.state.fl.gov.us)
USF	Universal Service Fund
USPS	United States Postal Services
UT	Universal Time
UTP	Unshielded Twisted Pair
UWC	Universal Wireless Communications

V	Volt (voltage)
V.90	*de jure* 56kbps modem standard compatible with the proprietary standards x2 and K56 Flex
VACC	Very short-run ACCess costs (conceptual model)
VAR	Value-Added Reseller
VBNS	Very-high Bandwidth Network Service
VBR	Variable Bit Rate
VDSL	Very high bit rate (data rate) Digital Subscriber Line
VeDSL	Voice-enabled Digital Subscriber Line
VHF	Very High Frequency (30-300MHz)
VPN	Virtual Private Network
VOATM	Voice Over ATM
VoDSL	Voice over DSL
VOFR	Voice Over Frame Relay
VOIP	Voice over Internet Protocol
VLR	Very Long Run
VSR	Very Short Run
VTOA	Voice and Telephony Over ATM
VTOA	Voice Traffic Over ATM
VTR	Very short-run TRansport costs (conceptual model)

W	Watt (electrical power)
W3C	World Wide Web Consortium
WAN	Wide Area Network
WATS	Wide-Area Telephone Service
WCD	Wireless Communications Division, FCC
WCS	Wireless Communication Service
W-CDMA	Wideband Code-Division Multiple-Access
WDM	Wavelength-Division Multiplexing (network)
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WWAN	Wireless Wide Area Network
WWW	World Wide Web
WYSIWYG	What You See Is What You Get

X.25	Packet-switched virtual WAN service (CCITT standard for analog lines)
X-DSL	Any type of Digital Subscriber Line
XML	eXtensible Markup Language
Y2K	Year 2000
ZBTSI	Zero Byte Time Series Interchange
ZCS	Zero Code Suppression (signaling)

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

CONVERGENCE OF TRADITIONAL TELEPHONY, ENHANCED TELECOMMUNICATIONS, PRIVATE DATA NETWORKING, AND THE INTERNET INTO HYPERCOMMUNICATIONS: IMPLICATIONS OF THE NEW ECONOMY OF THE NETWORK FOR FLORIDA AGRIBUSINESSES

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Florida agribusinesses will increasingly rely on networked hypercommunications services and technologies as agriculture becomes more information intensive. The telecommunications model requires separate networks, services, and devices for different message forms. The broadband hypercommunications model that is replacing telecommunications is based on a single, converged network that interconnects diverse services and devices. Hypercommunications use packet switching and digitization, allowing voice and high-speed data communications to be combined inexpensively. The growing economic necessity for high-speed access to hypercommunications in agriculture comes from the interaction of communication, technology, and information.

Powerful network effects from technical and economic properties of hypercommunications create two new economic realities for agribusinesses. First, a greater volume of communications and a wider choice of message types that can be sent over greater distances can be purchased for less cost using hypercommunications. Second,

hypercommunication services and technologies are complicated. In order to profit, agribusinesses need to understand the difference between bandwidth and data rate, wireline and wireless infrastructures, and source and signal domains. The four major services of traditional telephony, enhanced telecommunications, private data networks, and Internet are still sold separately, but new technologies allow them to be sold as one. Business benefits of convergence are so strong that buying services separately will become increasingly inefficient.

The high-speed access many agribusinesses need (or shortly will require) does not come automatically in Florida. In rural Florida especially, the wireline telephone infrastructure cannot support data rates of 14.4 kbps in some areas. The 1996 Telecommunications Act guarantees high-speed (200 kbps) access under universal access provisions, but it is estimated that it will be three to five years before 56 kbps speeds are universally available in Florida. However, competition among communication providers has led to the introduction of new wireline and wireless infrastructures for high-speed access.

Eighteen unique characteristics of agriculture, along with vertical and horizontal integration and cooperation and competitive strategies, are used to identify the unique hypercommunication needs of Florida agribusinesses. A portfolio strategy tree and a conceptual pricing model are used to simplify the decisions agribusinesses will be making about specific services and technologies as convergence occurs.

CHAPTER 1
OVERVIEW OF HYPERCOMMUNICATIONS AND FLORIDA AGRIBUSINESS

In 1913, G.F. Warren wrote what is still sage advice for U.S. agriculture.

> More farmers fail because of poor farm management than because of poor production. . . .The successful farmer must plan his work ahead of time. . . . He must foresee most things that are about to go wrong and prevent them from going wrong. [Warren, 1913, p. 2]

While the importance of good management has not changed since 1913, the scale and scope of agricultural enterprises have. Good management may be more essential than it was eighty-six years ago, not simply because enterprises are larger and more varied, but also because managers have had to adopt the technologies necessary to become bigger and more efficient. Information technologies will enable still greater efficiencies of span, scale, and scope as agribusiness enters the high tech information age. To remain competitive, Florida's agribusiness managers will use strategies designed to see into the turbulent future to efficiently adopt new technologies, manage resulting change, and be productive in a wider range of business activities. Agribusiness will increasingly rely on one information technology in particular, high tech communication (hypercommunication) to react to change, profit from change, and produce innovations that will create change.

Forecasting the impact hypercommunications will have on agriculture is difficult. According to the 17th Century philosopher Thomas Hobbes, "No man can have in his mind a conception of the future, for the future is not yet. But of our conceptions of the past, we make a future" [In Foner, 1998, p.38]. Agricultural history is replete with examples in which both optimists and pessimists ignored commercial and behavioral reality (because of excitement, fear, or pure boosterism) to yield highly erroneous predictions. Now, in the information age, a "forward looking" view dominates the discussion of how businesses will be almost instantaneously altered by high technology. Often, such predictions turn out to be far from the slower-paced reality because human adoption behavior tends to be backward looking. No matter how new hypercommunication services and technologies try to penetrate agribusiness, they must be solutions to real world problems in order for existing managers, employees, and stockholders to adopt them.

Experience is but one basis for predicting effects from the rapidly occurring changes in production, marketing, and communication stemming from the use of information technologies. Foner insists that institutional and value changes are forecasted better than forward-looking predictions of specific new technologies:

> I would like to propose the heretical idea that in thinking about the future, we pay less attention to predicting what changes will take place and more to the implications of different possible changes for existing values and institutions. [Foner, 1999, p.39]

Such an "heretical" view invites economic analysis of technological change, instead of promotional ballyhoo. This research will use description, theoretic example, and behavioral history to suggest some likely effects of hypercommunication on existing institutions (markets, for example). Then, the guesswork of normative predictions (such as the excess enthusiasm of the booster or the depressive pessimism of the doomsayer) is reduced or eliminated.

1.1 Introduction

The U.S. economy has been a giant laboratory where economic, marketing, and regulatory theories have been honed academically and tested empirically. Economic tools developed in this real world laboratory will be used in this study to draw an understandable map from an extraordinarily complex and dynamic set of services and technologies. Economic reasoning will provide clarity about what hypercommunications are bringing to Florida agriculture.

Florida has come a long way since before World War I when Warren wrote his advice on farm management. Changes in the agricultural economy have led the way. Hardy pioneer farmers, new settlers, a long growing season, widespread land reclamation, and the ready acceptance of new crops and ideas have driven Florida's agriculture. Florida's diverse agriculture has spawned a thriving agribusiness sector, which today employs over 15 percent of Florida workers[USDA, ERS, "Florida Fact Sheet", 2000]. Florida's farms and agribusinesses are second only to tourism in dollar value in the state's economy.

The transformation from backwater corner of the Deep South to a center of international agricultural trade has taken hard work. Plenty of investment, new farming technologies, and a communications-transportation network have rescued Florida from relative isolation. In 1920 for example, fewer than 10 percent of Florida farms had telephones compared to a national average of 50 percent [United States Census Bureau, 1924, p. 305]. Since then, urbanization has brought a better communications infrastructure while bringing greater pressure on land and water for agriculture, congestion problems for transportation, and a changing political climate regarding environmental concerns. Hypercommunications represent a way for many agribusinesses to operate more efficiently and profitably in the face of these constraints. In many cases, hypercommunications alter the constraints themselves by changing relative prices, expanding markets, and altering the possibilities for production, distribution, and marketing.

Generalizing, hypercommunication is defined as the ongoing technical and economic convergence of existing communication services into a single service, due (in part) to the interconnection of low-cost digital transmission networks. Hypercommunications also connote an "extensive domination" of "our social, economic, and political futures" because of its pervasiveness and currency [Stone, 1997, p.1]. Hypercommunications messages include (alone or in combination) telephone calls, voice mail, images, videos, faxes, text, digital pages, animations, data, sharing of computer applications, and e-mails. Hypercommunication services carry or create these and other kinds of messages using inter-networked hypercommunication technologies.

Hypercommunications connect businesses to circuit-switched networks such as the Public Switched Telephone Network (PSTN) and to packet-switched networks like the Internet. The PSTN carries a broad array of enhanced voice and data services in addition to long-distance and local telephone service. The Internet is an inexpensive (but often less reliable) packet-switched alternative that can provide voice, text, data, video, and graphic communications. The Internet allows both customers and suppliers worldwide to obtain information about businesses very cheaply, contact those businesses, conduct e-commerce, and more. Businesses also use private voice and data network services modeled after the Internet (such as Intranets, Extranets, and Virtual Private Networks or VPNs) to securely conduct internal communications. New hypercommunication services will continue to result from interconnection of previously separate devices such as telephones and computers, as in the case of CTI (Computer Telephone Integration).

Both new technologies and deregulation (brought about by the 1996 U.S. Telecommunications Act) are creating an imaginative, competitive market. Businesses are provided with affordable domestic and worldwide communication with customers, suppliers, and branch locations, even to individual salespersons in the field or telecommuters. Local and long-distance telephone companies, cable television and Internet providers, and even electric utilities are in the hypercommunications business.

Agribusiness refers to "the full scale of operations related to the business of agriculture" [Herren and Donahue, 1991, p. 9]. Information-intensive agribusinesses (especially those beyond the farm gate) have been early adopters of hypercommunications in agriculture. Hypercommunications can help agribusinesses obtain information needed to evaluate and implement improved technologies. Effective and efficient use of those improved technologies, in turn, enables agribusiness to profitably operate on larger scales and scopes than ever imagined. Hypercommunications management is at the strategic center of an economy where profits and growth are fueled by information and technology.

Economic concepts (such as informational advantage and economic efficiency) are vital in formulating hypercommunication strategies to give individual firms a competitive advantage. Agribusiness managers may be familiar with supply, demand, prices, and profits in their own markets. However, they also need to understand technical and economic essentials of hypercommunication markets to grasp the inherent opportunities and challenges of the information age. To examine the impact and usefulness of hypercommunications in agriculture, each chapter builds on preceding ones as shown by the pyramid in Figure 1-1.

Economics will help clarify how (and why) changes in information technologies are affecting farms, ranches, nurseries, processors, and vertically and horizontally integrated agribusinesses. However, economics cannot predict precisely where, how, or when changes in agribusiness because of hypercommunications will occur in Florida. Economics can help to identify what can go wrong and what can go right as the information superhighway reaches fields, processing plants, and agricultural marketing enterprises statewide.

The complexities of hypercommunications often lead uncertain managers to avoid formulating overall strategies, instead of relying on technical staff to propose short run contingencies. However, the sheer importance of information to profitability and growth now requires that agribusiness managers see the basic economics of how agriculture and hypercommunications fit together. Then, they can formulate integrated solutions that will yield positive results.

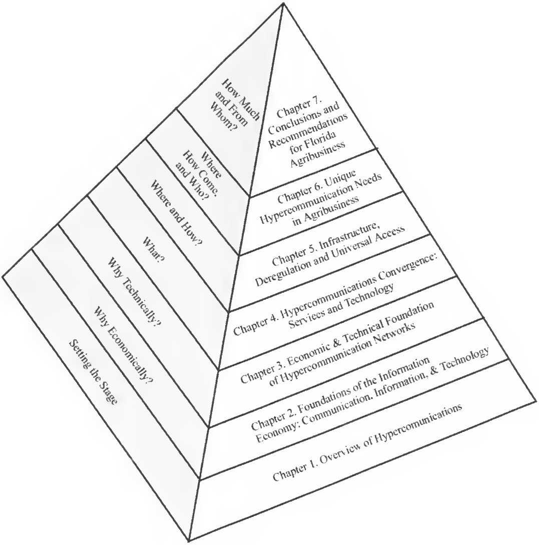
How Much and From Whom?
Where How Come, and Who?
Where and How?
What?
Why Technically?
Why Economically?
Setting the Stage
Chapter 7. Conclusions and Recommendations for Florida Agribusiness
Chapter 6. Unique Hypercommunication Needs in Agribusiness
Chapter 5. Infrastructure, Deregulation and Universal Access
Chapter 4. Hypercommunications Convergence: Services and Technology
Chapter 3. Economic & Technical Foundation of Hypercommunication Networks
Chapter 2. Foundations of the Information Economy: Communication, Information, & Technology
Chapter 1. Overview of Hypercommunications

Figure 1-1: Overview of Florida agribusiness-hypercommunications.

This investigation seeks to contribute to knowledge in an important, timely area. One part of that contribution comes from defining terms, beginning in section 1.2 with twelve essential concepts. Then, in section 1.3 the problem is defined to make the investigation possible. Research objectives and economic hypotheses are presented in section 1.4. Section 1.5 covers the scope and methodology, while section 1.6 provides justification for the research from within the paradigms of economics, agricultural economics, and the two marketing paradigms (agricultural and business). The final section of Chapter 1 gives an organizational overview of the remaining chapters.

1.2 Twelve Essential Terms

Now, definitions of twelve essential terms (including communications and hypercommunications themselves) are presented in Table 1-1, along with the location of their development in the text.

Table 1-1: Twelve essential definitions and their location in the text.

Term	Essence	Ch.
Communication	Transmission of message(s) from sender(s) to receiver(s) through a medium subject to noise.	2
Hyper-communication	Convergence of telecommunications, broadcasting, Internet and data communications into a single service that is reshaping how businesses, people, and government operate and think.	2
Technology	Applied science.	2
Information	The content of all message traffic is raw information (sometimes called data). Information technologies (especially computer hardware and software) and hypercommunications process and convey successively filtered and condensed messages into workable, organized units called information.	2
Bandwidth	Capacity of communications pipeline or channel.	4
Infrastructure	The hardware, software, networks, and other physical transmission media used so that hypercommunication occurs.	4,5
Universal Service & Universal Access	Terms describing the government policy objective that everyone, regardless of location or income, be provided affordable access to advanced communication services.	5
Quality of Service (QOS)	1) Objective or subjective measure of hypercommunications service delivery. 2) Hierarchy which determines the urgency, method, time, and price of communicating a particular message.	4
Bundling	The combination of individual services into larger, unified products.	6
Packet Switching & Circuit Switching	Two methods of message transmission through a network. Circuit switching implies that an entire message or conversation travels real time over a single physical connection between sender and receiver. Packet switched messages travel in parts (or packets) often through shared connections.	3,4
Digitization	Characteristic of information source domain (signal domain) whereby information is created (transmitted) as a series of ones and zeros rather than continuous levels.	3,4
OSI Layers	Levels of network interconnectivity, security, and infrastructure.	3

Taken together the concepts in Table 1-1 form the foundation of an elementary hypercommunications vocabulary. Further discussion of these and other essential terms is presented later where their importance to agribusiness hypercommunications can be presented in the appropriate context.

1.3 Problem Statement

The definitions in Table 1-1 demonstrate the breadth of hypercommunications. While the role of hypercommunication in the economy is important to agriculture, the focus of this research is on the role of hypercommunication in agribusiness. Therefore, specific agribusiness hypercommunications-related problems rather than general problems will be addressed. This research is confined to three essential problems:

1. To counteract the attitude that agriculture does not need hypercommunications.
2. To understand agriculture's unique communication needs.
3. To focus agribusiness hypercommunication strategies and decisions by applying economics and marketing of hypercommunication technologies and services.

The first problem is the attitude that high tech hypercommunications and computer networks are for information and computer service industries, but not for agriculture. According to this attitude, sectors with heavy information flows such as financial services or consumer retailers such as book and music publishing need hypercommunications networks, but pre-information economy industries such as agriculture do not. While it is true that most agribusinesses sell raw or processed agricultural goods and not raw or processed information, information age communication strategies affect all industries, including agriculture. Clearly, Amazon.com has different communication needs than a Palm Beach County wholesale nursery. However, the information age is even changing wholesale plant markets because the economics of serving customers and running a business are in some ways similar to publishing.

Agribusiness' unique communication and information needs form the second problem. If celery from Florida fields sits un-refrigerated in the sun at a railroad transfer point for one day, it goes bad and cannot be resold. Yet, a shipment of books from amazon.com can easily be restocked into inventory if it is waylaid. The uniqueness of agriculture generates a set of unique agricultural hypercommunication needs.

Agriculture's uniqueness stems from factors such as seasonality of supply and demand, weather and pests, quality variation, storability, price instability, international trade, transportation logistics, labor, and food security. Since food is essential to human life, agriculture is an indispensable industry with a unique set of government and public relations as a direct result. Together these factors help create a unique interlocking structure, conduct, and performance of input and output markets that form the agribusiness complex.

Figure 1-2 shows how agriculture's uniqueness creates a unique set of communication needs. The figure shows some representative agribusiness communication needs based especially on the level of horizontal and vertical integration. Note that factors such as size of firm, unit value of product, nature of selling process, search costs, and a variety of other factors specific to each agricultural sub-sector and region also create unique communication needs.

Within the second problem is an unresolved policy issue that confronts all businesses with rural communications lifelines: availability and cost of advanced hypercommunication services in rural locations. This is most critical the closer to the farm gate an agribusiness operates. There is a rich history of regulation, deregulation, re-regulation, subsidy, and taxation underscoring federal and state "universal access" policies mandating that advanced communication services be provided affordably to rural areas. Although some agribusinesses have offices inside class A "smart buildings" in urban Florida, their weakest and most expensive communication links tend to be rural or international. In addition to agribusiness' ability to horizontally communicate, the economic futures of the small communities in which they operate are affected by agribusiness communications as well.

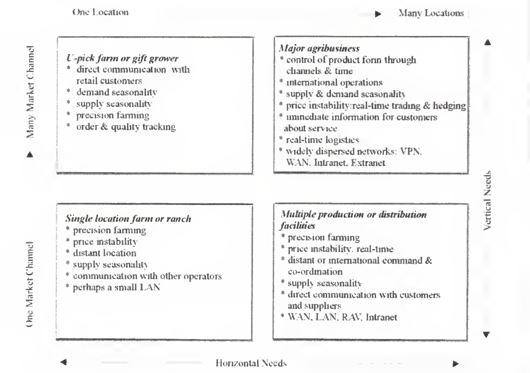
One Location
Many Locations
Many Market Channel
One Market Channel
Vertical Needs
Horizontal Needs
U-pick farm or gift grower
* direct communication with retail customers
* demand seasonality
* supply seasonality
* precision farming
* order & quality tracking
Major agribusiness
* control of product form through channels & time
* international operations
* supply & demand seasonality
* price instability:real-time trading & hedging
* immediate information for customers about service
* real-time logistics
* widely dispersed networks: VPN. WAN. Intranet. Extranet
Single location farm or ranch
* precision farming
* price instability
* distant location
* supply seasonality
* communication with other operators
* perhaps a small LAN
Multiple production or distribution facilities
* precision farming
* price instability. real-time
* distant or international command & co-ordination
* supply seasonality
* direct communication with customers and suppliers
* WAN, LAN, RAV, Intranet

Figure 1-2: Unique agribusiness communication needs based on horizontal-vertical integration.

The first problem was to address the attitude that hypercommunications are not needed in agriculture. The second problem went beyond equating agribusiness hypercommunication needs to other industries, to identify the unique communication needs of agribusinesses. If businesses generally need hypercommunications and if agribusinesses have unique needs to be served, then the third problem is to help agribusinesses understand how to develop customized hypercommunication strategies and decisions in an economic and marketing context.

While hypercommunications is a highly technical subject, this research is business oriented. Therefore, an applied economic and marketing business focus on agribusiness hypercommunications cannot give the whole picture. Figure 1-3 dramatizes this by showing a technical-business continuum along which hypercommunication decisions are made. The economics and marketing orientation of this research establishes a philosophy firmly on the "business" end of the imaginary continuum. Assume that a business philosophy was used to establish an overall hypercommunications network strategy, which guides decisions along the continuum. The technical aspect is used to achieve the mission and objectives of the agribusiness rather than molding the agribusiness to fit technology.

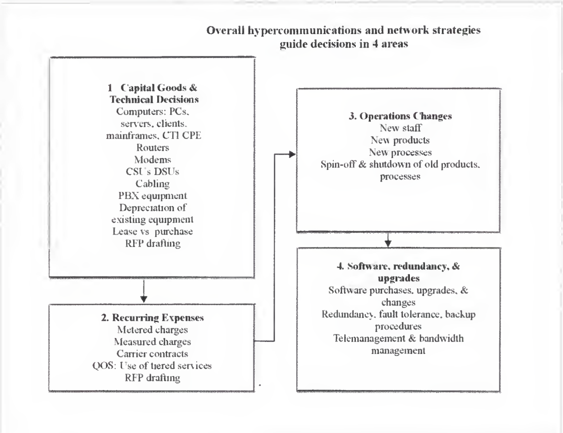
Overall hypercommunications and network strategies guide decisions in 4 areas
1 Capital Goods & Technical Decisions
Computers: PCs, servers, clients, mainframes, CTI CPE
Routers
Modems
CSU's DSUs
Cabling
PBX equipment
Depreciation of existing equipment
Lease vs purchase
RFP drafting
2. Recurring Expenses
Metered charges
Measured charges
Carrier contracts
QOS: Use of tiered services
RFP drafting
3. Operations Changes
New staff
New products
New processes
Spin-off & shutdown of old products, processes
4. Software, redundancy, & upgrades
Software purchases, upgrades, & changes
Redundancy, fault tolerance, backup procedures
Telemanagement & bandwidth management

Figure 1-3: Technical-business hypercommunications decision continuum.

Figure 1-3 is not meant to imply a precise cutoff between decisions that are in the realm of engineers and computer personnel from those that are in the realm of business managers (represented in this research by economics and marketing). The entire enterprise will have to be involved in decision-making based on an overall hypercommunications strategy. This research is designed to acquaint management with some technical fundamentals while focusing on managerial competencies in marketing and economics. Additionally, technical personnel must be acquainted with business fundamentals while focusing on their technical competencies.

While the left (purely technical) end of Figure 1-3 contains activities like equipment programming and installation of Wide Area Networks (WANs) and LANs, such topics are outside the realm of this research but still within the realm of business judgment. Those on the far right such as capital budgeting, along with front and back office hypercommunications procedures, are likely to stem directly from economic and marketing considerations. In the center panel of decisions and activities in Figure 1-3 are examples of a wide middle ground between the technical and business ends of hypercommunications decisions. This research focuses on helping agribusinesses to make decisions in the center of the continuum based on the interaction between economics and technological change. However, this research does not seek to provide the technical, engineering or computer science expertise needed to sharpen business strategies into specific technical tactics.

1.4 Objectives and Economic Hypotheses

1.4.1 Objectives

The investigation has six chief objectives:

1. To explain *why* hypercommunications are essential (economic origins).
2. To conceptually define *what* hypercommunication services and technologies are.
3. To consider *where* and *how* hypercommunication infrastructure and markets form (and their impact on Florida agribusiness) through historical and economic analysis of policy regarding rural access to advanced hypercommunications.
4. To help both hypercommunication buyers and sellers understand the unique communication needs of Florida agribusiness and propose possible hypercommunication solutions.

5. To give agribusinesses real world ideas of both the usefulness (*how come*) and costs (*how much*) of various hypercommunication services and their regional availability across Florida.
6. To suggest strategic implications and recommendations for agribusiness because of changes in the structure, conduct, and performance of the hypercommunications market and because of structural changes in the agricultural input and output markets due to hypercommunications.

The first objective is to show how the economics of technology, information, and communications networks have created an information economy. Technology, information, and networks exert a synergistic influence on how communications occur, why communications occur, and on the relative prices of communications and information searches. Economic reasoning will trace why hypercommunications exist by examining the economic origins of hypercommunications from the information economy.

Objective two is to conceptualize hypercommunication services and technologies understandably. This is done by providing technical descriptions of services and technologies and by clearly defining terms. With the Federal Government's own admittedly *incomplete* "Glossary of Telecommunications Terms" containing over five thousand terms [GSA, 1996, *FED-STD-1037C*], selectivity is important. Twelve significant terms have already been introduced. An understanding of these, along with elementary technical descriptions of services and technologies, will simplify the complexities of hypercommunications into usable agribusiness hypercommunication strategies. More detailed economic and technological conceptualizations translate the *what* of hypercommunications into specific solutions of unique agribusiness communication needs. Additionally, a glossary (in the appendix) helps the reader become conversant in both hypercommunications terminology and acronyms.

The third objective focuses on implications for agribusiness from federal and state policies that are designed to help rural areas preserve their economic bases, while creating the developmental chain reaction necessary to adapt productivity and infrastructure to the information age. The first link in the chain is a high-speed hypercommunications infrastructure to provide state-of-the-art access to the information superhighway. Next, workers and businesses will have to learn the benefits of adoption, be trained on hypercommunications hardware and software, and, most importantly, improve their information literacy skills.

Agribusiness adoption of hypercommunications is a catalyst for an information chain reaction that will spur economic growth in many sectors of rural Florida's economy. Economic and marketing models of technological change can help explain and analyze past, current, and future extension of hypercommunication services to rural and agricultural Florida. Additionally, under this objective, possible losses to agribusinesses in under-served areas from lack of infrastructure and local multiplier effects are considered.

The fourth objective concentrates on showing how agribusiness hypercommunication needs depend on factors inside and outside the individual firm. Outside the firm, traditional agricultural sub-sectors and marketing channels as well as innovative new business activities of competitors influence a particular firm's needs. Inside the firm, the degrees of vertical and horizontal integration are especially important to hypercommunication needs. Additionally, departments inside each agribusiness have their own strategic concerns regarding hypercommunications. Advertising and marketing, administration and production, recruiting and human resources, transportation and logistics, research and development, receivables and payables, and (of course) computing and telecommunications each have needs. Unless managers are careful, the hypercommunications strategic process can lead to turf wars and infighting in large firms. For smaller firms without distinct departments, a lopsided strategy can still harm specific functions. Another part of this objective is to help hypercommunications carriers understand the geographical diversity and potential profitability of serving agribusinesses.

The usefulness mentioned in the fifth objective depends on the needs identified through the fourth objective. Importantly, the usefulness also depends on the sixth objective because agribusinesses will function differently because of information technologies since agricultural input and output markets are themselves altered by hypercommunications. Cost is also linked to the changes in hypercommunications market structure mentioned next in objective six. The operative term in this objective is "real world". This research is designed to produce hypercommunication solutions (with an idea of the economic costs and benefits involved) that are directly applicable to Florida agribusiness needs.

As agribusinesses purchase hypercommunications inputs from a fast-changing market where computer and telephone networks are converging, there are enormous implications on the profit maximizing quantity of hypercommunications to be bought, depending on the competitiveness of the hypercommunications market. Hypercommunications is often characterized as a decreasing cost industry in which an increasing number of competing services are sold based on technologies that offer increasing returns to scale and size. Yet, the number of hypercommunications firms is falling with frequent merger announcements. In many cases, only one or two firms serve a particular local marketplace, so that an agribusiness may have few competitive choices when buying services. This research will examine these apparent tradeoffs.

Hypercommunications can help agribusinesses sell output directly to the public to achieve a degree of product differentiation and provide convenient ways around traditional middlemen. The same is true for input purchases. This reality is dramatically transforming other industries ranging from travel agents to stock brokerages. This objective applies the experiences from other industries to examine the transformation in agriculture. Examples range from honey producers with e-commerce websites to sophisticated CTI call centers selling the wares of gift fruit stands or greenhouses. In other cases, farms and ranches have created new profit centers such as u-pick fields and agri-tourism destinations such as guest ranches and farm bed and breakfasts. Such ideas can actually help marginal producers remain in business by changing the product and the target market. However, an e-agribusiness must be able to use hypercommunications to attract and communicate with customers.

1.4.2 Economic Hypotheses

Hypotheses are conceived *a priori*, without certainty that they can be measured. Hypercommunication services, technologies, and market conditions are evolving so rapidly that there is little time series data available to statistically test economic hypotheses. Therefore, most hypotheses will not be statistically testable. Nonetheless, a contribution to the agribusiness field will still be produced. Pertinent literature will be reviewed, a hypercommunications technology and service taxonomy devised, and useful research objectives achieved.

Four hypotheses have important implications for agribusiness hypercommunications:

1. The roles of infrastructure development and hypercommunications adoption rates in future economic growth: today's low infrastructure growth (or lack of adoption) is tomorrow's decayed competitive position.

2. Regulatory barriers and unequal tax treatment of hypercommunications sub-industries: asymmetric regulation and taxation produce hypercommunications supply market inefficiencies that are, in turn, transmittable to agribusiness input and output markets.

3. Technologically induced time compression means shorter periodicities: decision periods are increasingly shorter time intervals. Rapid technological change (as transmitted through hypercommunications and information technology) means delay in adopting technology is more costly now than when decision periods were longer. Furthermore, while there is less time to adjust to new information and technologies, plant and animal growth cannot be sped up into shorter periodicities through information technologies.

4. Networks and information each have unique economic properties: costs and benefits of information networks (made easier through hypercommunications) are not explicitly priced in markets.

These four hypotheses guide the study. The research cannot logically prove or disprove any one of them, but they are considered as useful possible representations of new economic realities for Florida agribusiness.

1.5 Scope and Methodology

1.5.1 Scope

There are several dimensions to the scope of this research including place, market definition, academic field, time, and technical level. This study considers hypercommunications in general and then focuses on Florida agribusiness hypercommunications. Many such markets (which are just beginning to emerge from deregulation and infancy) consist of the general supply and demand for hypercommunication services and technologies. Services will be supplied by current and potentially available bandwidth delivery technologies ranging from traditional narrow-band telephone copper wiring to fiber optics and wireless. Also, the supply of hypercommunications includes services (ranging from local and long-distance telephone to Internet access and e-mail) and their current and potential availability to the agribusiness target market. Strengths and weaknesses of Florida's current hypercommunications infrastructure are emphasized.

On the demand side, the scope includes potential and current agribusiness hypercommunication needs and benefits. The options available to agribusiness will be discussed within the contexts of profit maximization and marketing strategy. The result, hopefully, will be useful extension-style “descriptive” research that is accessible but detailed enough to give theoretically oriented readers ideas for future work.

The scope within the field of agricultural economics covers topics from many sub-disciplines. Topics from the literature of these sub-domains of agricultural economics will help accurately describe the agribusiness hypercommunications situation in Florida generally and in particular topical areas. Table 1-2 shows the scope of thought from within agricultural economics to be brought to bear on the problem.

Table 1-2: Scope of agribusiness hypercommunications research within agricultural economics sub-disciplines.

Sub-Discipline	Topicality for Agribusiness Hypercommunications
Production economics	Hypercommunications as input, hypercommunications production.
Agricultural policy analysis	Analysis of taxation and regulation of hypercommunication services.
Transportation economics	Networking, flow-management models. Source of agribusiness communication needs.
Environmental economics	Source literature for network externalities, tragedy of the cyber commons.
Agricultural marketing	Source of agribusiness communication needs, locational theory, market definition and segmentation, market channels, derived demand, etc.
Agricultural finance	Sources of agribusiness communication needs, cash flow analysis of hypercommunications inputs, outputs, and infrastructure project analysis.
Land economics	Valuation of property because of accessibility of hypercommunications, fixity of assets argument.
Industrial organization	Market structure, conduct, and performance.
Agribusiness management	Internal and external communication needs and hypercommunications strategy development.
Rural development	Regional development implications based on telecommunications and geography.

The academic scope is even broader than the fields within agricultural economics listed in Table 1-2. A recent explosion in general economics sub-disciplines including regulatory economics, Internet economics, network economics, and research agendas in the economics of technical change has produced additional relevant literature. Business and agricultural marketing team together to produce an interesting literature overlap on topics like pioneer entry. Another theme is the study of innovation management in industries that are often dominated by the ubiquitous genius-entrepreneur, popularly described as a technical expert, but a novice in marketing, management, and finance. The general marketing literature is consulted in the areas of services marketing, entry advantage, the adoption process, and diffusion of innovation. The results will rest on a positive synergy of multi-disciplinary work. Such a wide academic scope helps the research overcome the lack of data and long-term experience in the exponentially growing hypercommunications industry. However, the width of the scope means that important work will have been missed in each field.

The research also has a geographical scope in terms of the rural infrastructure and its impact on Florida agribusiness hypercommunication needs. It is important to realize that the word rural and the word agriculture are not synonyms. Much agribusiness (especially the nursery-greenhouse industry and the transportation, processing, and retail functions) is situated in Florida's urban areas while less than 3 percent of Florida's rural residents are farmers [University of Florida, 1993, p.5]. Much of rural business activity is not agriculture-related. Hence, the communication needs of agriculture take place in urban, suburban, and rural locations.

The focus of the study is the period after the 1996 TCA (Telecommunications Act) was adopted. However, the history of hypercommunications and Florida agribusiness will prove a useful brake on the excesses of a forward-looking scope. As Taylor and Taylor mentioned in 1952:

> The historical method is indispensable to the understanding of institutions which give form and effectiveness to the policies affecting agriculture. It is often true that in the abstract a given policy … seems rational. Yet a policy quite different is adopted and institutions or agencies are set up to administer legislatively established regulations which conform more closely to the grooves of logical thinking. [Taylor and Taylor, 1952, p.277]

The scope of this research is skewed towards recency on market development, but many hypercommunication technologies and services are hardly new. Technological and market histories retain a backward-looking focus designed to look at overall implications of hypercommunications for the existing institutions of agribusiness and markets.

Time and budget prevent the application of this research beyond Florida's borders. While considerable effort has been put into studying national and international trends in hypercommunications and agribusiness, no effort will be made to generalize results to U.S. or international agribusiness. Other limitations include a rapidly changing amount of technical and market information, lack of freely available proprietary information, and the necessity of providing confidentiality to background sources within both agribusiness and hypercommunications industries. The lack of time series and econometric data is hardly surprising in such a new and developing industry, but are limitations nonetheless.

1.5.2 Methodology

According to some philosophers of science, the scope of admissible inquiry is limited by demarcation criteria that separate intellectual activity into mutually exclusive classes of science and non-science [Popper, 1959]. Indeed, these demarcation criteria are behind one definition of methodology given by Fritz Machlup:

> I submit that we understand by methodology the study of principles that guide students of any field of knowledge and especially any branch of higher learning (science) in deciding whether to accept or reject certain propositions as a part of the body of ordered knowledge in general or of their own discipline (science). [Machlup, 1979, p.54]

However, some economists argue that rhetoric and metaphor are more important in economic research than methodological purity. McCloskey supports this view:

> Economists do not follow the laws of enquiry their methodologies lay down. A good thing, too. If they did they would stand silent on human capital, the law of demand, random walks down Wall Street, the elasticity of demand for gasoline, and most other matters about which they commonly speak. In view of the volubility of economists the many official methodologies are apparently not the grounds for their scientific conviction. [McCloskey, 1983, p.482]

The next section (1.6 Justifications) will justify this research within the *methodology of economics*, while this section covers general *research methods*. This section considers the general methods employed to achieve the research objectives from section 1.4, while the next section justifies those objectives and the research topic itself within economic science. In section 1.7, specific research methods used within each chapter are given during the organizational overview.

There are five general research methods: literature reviews, collection of data, reduction of those data into information used, examination of hypotheses, and reproducibility of results.

Each general research method attempts to achieve one or more research objectives by considering the appropriate hypothesis.

A set of broad literature reviews is the first general research method, rather than an intensive review of one particular strain of literature around which a conceptual model is developed for rigorous statistical testing. Because of the relative newness of the subject area and the rapidity with which hypercommunications convergence, structural change, and technological changes are occurring, the set of reviews is mainly confined to surveys and seminal articles in several areas. Where the topic itself is so new that peer-reviewed literature is not yet established because of reviewing lag time, timeless economic foundations are applied to available working papers and other academic sources.

Data collection is a second general research method. Both primary and secondary data were collected. Most data were secondary (collected by someone else) with primary data consisting of confidential personal interviews or summaries resulting from the organization and sorting of secondary data. The data collected were of several kinds: factual, observational, geographical, or numerical. Factual data were generally secondary, including technical properties, details of services and technologies, current and planned availability of hypercommunication services throughout Florida, and scientific definitions. Observational data include characterizations given by firms and regulatory agencies, results of researchers, and the personal observation of hypercommunication services and technologies. Reviews of academic literature, other scientific publications, and other material used data that could best be characterized as factual and observational depending on the nature of the sources.

Almost all geographical data were gathered from secondary sources including franchise areas of over a thousand cable TV service areas, hundreds of local telephone exchanges, coverage zones of other service providers, and other important boundaries. Sources of these data were primarily from regulatory agencies and filings.

Secondary numerical data concerning prices, customers, and descriptive statistics of Florida agribusiness were gathered from many public and private sources. Asymmetric regulation has created an asymmetry of data about market services, prices, and service locations. There is enough public information regarding services provided by telephone monopolies to describe their operations in detail, but the public availability of pricing and other operational data for other hypercommunications firms varies.

Reduction of these data into economic generalizations for agribusinesses is the next general research method considered. Since the task of enumerating fast-changing hypercommunications supply is vast, it is impossible to provide a precise snapshot of services, prices, and technologies available in every locality. Instead, an overall economic analysis of data generally affecting agribusiness in all areas of Florida was made. For each service and technology, technical material, legislative and regulatory publications, industry sources, and trade publications were consulted to yield reasonable summaries. Reduction of data into specific suggestions for agribusinesses focused on summarizing and filtering a dense set of prices, service bundles, and hypercommunications suppliers into a summary.

The general method used to state and develop hypotheses is another concern. Here, the research method used is clearly closer to McCloskey's "rhetoric of economics" than to any formal logical construction of theorems, lemmas, and proofs. Specific research methods used to gather and reduce data supporting a particular conclusion will be given in context.

Finally, the reproducibility of these results is an important general research method. Typically, consultation of appropriate references is all that is needed to clear up a particular point. Such references may include reports or other information from web pages or other unpublished material. In these cases, a hard copy has been kept of all relevant documents and data. While some implications for agribusiness strategy are supported by proprietary sources that cannot be revealed, in no case is such evidence necessary or sufficient for the conclusions given. The recommendations will not hold identically forever because of the extreme volatility of hypercommunications. However, it is for this reason that implications have been kept objective and timeless as possible.

1.6 Justifications

Many argue that the ultra-modern hypercommunications market does not play by outdated economic rules. It breaks them. Such critics of traditional economics contend that the boundless, exponential growth of unconventional hypercommunications is opposite the simplistic, *ceteris paribus* world of conventional economic thought. Bill Gates seems to support this view in his 1995 book *The Road Ahead* (meant literally to refer to the hypercommunications information superhighway) "You can't count on conventional wisdom. That only makes sense in conventional markets"[1] [Gates, 1995, p.35]. The theory is that somehow the computer and hypercommunication markets are so different from other industries that economic theory is too simplistic and dated to apply. Rectification of this error forms one justification of this research.

Others argue that agriculture is doing quite well without high-speed Internet access, IP multicasting, and other hypercommunication services and technologies designed for the complexities of urban living and information-based businesses. Another justification of this research is to show that (in spite of opinions to the contrary) advanced hypercommunications is economically necessary for Florida agribusiness.

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[1] It is not to be implied that Mr. Gates either agrees with the economics naysayers, or is just posturing. Indeed, the federal government charges that Microsoft is quite aware of the conventional economics of both monopolistic and monopsonistic practices. Gates, who laughs off regular ditching of his Harvard "graduate level" economics class, has perhaps now become intimately familiar with economic theory. Microsoft has grown from Gates alone in 1975 into a multinational corporation. It is now a leading manufacturer of software and an important hypercommunications player, owning the leading web browser, its own ISPs including MSN and WebTV, portal sites such as MSNBC, and interests in AT&T's cable TV and telecommunications ventures. Microsoft also is a leader in the research and development of hypercommunications technology, though it allegedly has used its power in input and output markets to force competitor's products out of the market. In addition to the Department of Justice complaint, the firm is criticized for two anti-competitive practices. First, deliberate contamination strategies where software or hardware bugs can only be "cured" by purchasing additional Microsoft products. Secondly, for driving ISPs to acquire PC-based Microsoft web hosting equipment when the idea of the Internet was based on open interconnection.

Another justification comes from possible contributions to hypercommunications economics from the domain of agricultural economics. Production economics has long been in the agricultural economist's domain. In the information economy, populated with e-businesses, it would almost appear as though production economics was passé. After all, virtual space seemingly has no physical limits. However, production is essential to hypercommunications suppliers and customers alike because of the tradeoff between QOS (Quality of Service) and price. America Online before the Netscape and Time Warner acquisitions is one example. Federal authorities forced the company to run corrective advertising disclaimers in the mid-1990's that admit that the company oversold its modem lines and warn customers to expect busy signals. The profitability of an ISP or other bandwidth carrier depends on balancing "busy hour" customer usage loads with plant expansion and system downtime maintenance within certain known failure-success rates. Hypercommunications is a service with QOS easily measured with applied production technology models such as statistical multiplexing and Poisson distributions.

Agribusiness needs justify the research as well since hypercommunications are purchased inputs and sometimes provide direct revenues to agribusinesses. Web sites for Florida agribusinesses such as www.kingranch.com[2] or www.southerngardens.com show agribusiness has a hypercommunications presence on the World Wide Web (WWW). However, the wide geographical communications footprint of many agricultural operations and their relative distance from urban information centers populated with "smart buildings" and fiber-optic backbones sentences many agribusinesses to poor communications networks compared to non-agricultural firms.

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[2] There are enough Texans on my committee that I had better make it clear: King ranch is headquartered in South Texas, but also has South Florida sugar and sod operations.

Just to survive, many agribusinesses will have to become e-agribusinesses depending on product mix, attitude towards innovation, actions of suppliers and customers, horizontal-vertical integration, and the information literacy of staff. Optimizing the quantity of hypercommunications a profit-maximizing firm should purchase from a set of competing sellers is not a simple problem. Whether the discussion centers on bandwidth or broadband, terminology and pricing are confusing and complicated, sometimes deliberately so. Economic research is justifiably brought in to simplify these complexities into prices, markets, and constraints, all three readily understood by agribusiness managers.

Because of the protracted time it takes to understand another technological transformation of agribusiness, decision-makers are slow to adopt untried, new hypercommunication solutions because of the inherent risk. This research may help identify strengths and weaknesses of business hypercommunication strategies, thus lowering the risk that comes from fear of the unknown.

1.7 Organizational Overview

Chapter 2 and Chapter 3 address *why* hypercommunications originated. The separate communication markets that are converging into a single hypercommunications market were born because of specific economic reasons. Chapter 2 defines (and gives economic conceptualizations to) three foundations of the information economy: communication, technology, and information. The roles played by data, information, and communication in creating economic growth and innovation are discussed along with some implications for agriculture.

Hypercommunications' place in the information economy also requires some understanding of the economics of information. A hypercommunications service contract between a buyer and seller requires a legal "meeting of minds". However, perfect knowledge of every underlying technical detail is not needed for such markets to function. For example, consumers and businesses are able to purchase new automobiles without understanding the physics of the engine. On the other hand, if one party to a transaction has consistently superior information, there is an opportunity to earn excess economic profit. Agribusinesses (like other businesses) often end up paying more than necessary when their unfamiliarity with hypercommunications is transparent to vendors. For a variety of reasons to be discussed in Chapter 2 and Chapter 3, poor decisions about hypercommunications can ricochet through an entire company, region, or industry. This is also true of good decisions. Note that with superior hypercommunication strategies, an agribusiness can gain advantages in its own agricultural markets, even if the firm has an absolute or relative informational disadvantage.

Chapter 2 will use several methods to support the discussion. First, economic conceptualizations of information, technology, hypercommunication, and communication will be developed. Second, a discussion of the economic implications of several popularly held views of the "unlimitedness" of hypercommunications will be developed. Third, literature reviews of economics papers will cover path-breaking results in the economics of information and technology. Ideas in the chapter are developed from endogenous growth literature, induced innovation hypothesis, evolutionary school and path dependent development literature. In addition to peer-reviewed literature, scholarly books, working papers available on the WWW, reports from think tanks and trade associations, and material from regulatory agencies help to develop the chapter.

Chapter 3 discusses the economic and technical foundations of hypercommunication networks. On the technical side, the fundamental properties of networks are discussed. This technical discussion gives an overview of the economic underpinnings of telephone and computer networks. Results from operations research and network engineering further the coverage, helping to show the technological basis behind the convergence of voice, data, and video networks into a single hypercommunication network. A solid technical understanding of networks is important to applying relevant literature from the economics of networks to the hypercommunications case. Investigation is made of claims from the "new" economics that economic theory is useless in an information economy that is based on computer networks. Some claims are pseudo-scientific, remarkably similar to the modified production economics and popularized idea of unlimited communications, discussed in Chapter 2. Other claims that a "new" "weightless" economy has replaced the conventional industrial one are based on recent strains from the network economics literature. One example concerns positive externalities of networking whereby a business can benefit from communication networks without having to pay the full costs of information or network development. The technical discussion proves vital to understanding what part of network economics applies to hypercommunication networks, as well as what proportion of new economics is new and what proportion is actually economics.

Several methods support the discussion in Chapter 3. First, the networking literature from telephone and computer engineering is brought to bear on the technical foundations of pre-hypercommunication networking. The multi-disciplinary operations research literature is seen as the *modus operandi* through which voice and data networks are converging into a hypercommunication network. Throughout the technical discussion, the engineering objectives and technological constraints of many optimization models involved in hypercommunication networks are presented. Third, literature reviews develop the concept of network externalities and relate it to the role played by information networks as catalysts of the information economy. Source material is not restricted to peer-reviewed literature in the chapter. In many cases, working papers or industry white papers prove to be helpful.

If the information economy is the *why* behind hypercommunications and their necessity in agriculture, then more must be known about *what* hypercommunication services and technologies are. Chapter 3 presents technical and economic details about hypercommunication networks as it covers why hypercommunications drive the information economy. Chapter 4 expands on this foundation to create a technical introduction to hypercommunication services and technologies. Here, more detail is presented on hypercommunication sub-markets: services ranging from telephony to Internet access along with carrier and content technologies.

High technology creates new kinds of services of interest to agribusiness, putting others within budgetary reach, as hypercommunications prices fall and newly deregulated markets become more competitive. However, hypercommunications has economic constraints beyond short run accounting costs. Distance still constrains communications, but (thanks especially to packet switching) less than it did at one time.

Businesses face another important hypercommunications constraint: bandwidth. Bill Gates gives a simple definition of bandwidth as " . . . a measure of the number of bits that can be moved through a circuit in a second." [Gates, 1995, p. 31]. Bandwidth (or capacity) constrains the amount of information that can be sent or received. No business advantage can be obtained if particular location has insufficient infrastructure capacity or hypercommunication services are not affordably offered.

Several research methods support the development of Chapter 4. First, numerous technical sources (articles, texts, white papers, and standards) were consulted to provide an overview of the most important hypercommunication technologies and services. Additional understanding is acquired through review of trade publications and by informal discussions with industry sources. Where possible, deployment of services was also examined firsthand: business customers and hypercommunications suppliers were asked about their experiences and expectations. Material was gathered from websites of standards groups, technology manufacturers, service providers, and regulatory agencies.

Chapter 5 discusses the *how* and *where* of hypercommunications infrastructure and convergence. Deregulation, re-regulation, and other policy concerns such as universal access and service taxation are important to where and how hypercommunication services will be offered. Convergence and infrastructure development are extremely important to agriculture because the rate at which they occur is markedly different between rural and urban areas, or among regions of the state. Re-regulation, taxation, and other policies are meant to speed up the development of infrastructure in markets that have been missed by the uneven pace of competition. The current development pattern of Florida's hypercommunications infrastructure helps answer *when* agribusinesses can expect particular services to be widely available. Federal, state, and local governments have a variety of policy mechanisms designed to ensure rough parity among geographic locations in Florida. However, the regulations themselves can often lead to barriers to entry, service, and competition.

The development of Chapter 5 was based on several research methods. Review of academic literature provided a basic conceptual foundation. Policy options were considered using economic literature as a foundation along with regulatory staff reports and rulings, industry comments, texts, and trade press articles. A simple conceptual model of hypercommunications pricing and taxation is also introduced.

Chapter 6 covers the unique hypercommunication needs of agribusiness demanders. The main question to be considered is "*How come*" a specific agribusiness should employ hypercommunications. From the point of view of agribusiness, there is a derived demand for hypercommunication services, based upon profit maximization, cost minimization, or other goals of the firm. Emerging new technologies have spawned concepts such as e-agribusiness, website design, and Internet promotion. These concepts relate to unique communication needs within categories of agribusinesses that hinge on the identification of *who* needs hypercommunications the most (among agribusinesses and agricultural sub-sectors).

Importantly, the impact of high tech hypercommunications has important effects outside hypercommunication markets. Hypercommunication services are more than ordinary inputs and outputs. Information obtained by the firm and exchanged within it can profoundly affect input and output markets for many goods and services, including agricultural products and services. Hence, the pricing and competitiveness of Florida's *hypercommunication markets* have important interaction effects on Florida's *agribusiness* input and output markets.

The word markets is plural for two reasons that are covered in Chapter 6. First, there are many hypercommunications service markets: local telephone, long-distance telephone, Internet access, wireless telephone, and computer networking are but a few. Bundles from these individual sub-markets will eventually converge into one hypercommunications service *market*. Second, a different hypercommunications marketplace exists for thousands of specific locations in both urban and rural Florida. Every city, county, local telephone exchange, local cable TV franchise, and wireless service area (and all combinations) are examples of such market boundaries.

There are two chief ways hypercommunications improve agribusiness profits and growth. First, networked hypercommunications can cut the costs of supervision, control, and sales, while simultaneously allowing firms to operate on larger scales or wider scopes. Such results come from changes in the firm's front office (marketing and customer service) and back office (administration and manufacturing) technologies.

Second, information gathered through hypercommunications can change front or back office operations through technology spillovers. Technology spillovers occur when new knowledge is obtained directly and indirectly through hypercommunications, encouraging innovation throughout the firm. Innovation may be from product and systems development (such as a new invention or process that enables increased production while cutting costs or a new idea that frees resources allowing production of new items). Alternatively, the direct innovations may include the creation of information sales or other services. Hypercommunications can also create indirect innovation when new ideas help land, labor, capital, and management become better synchronized and more efficiently used.

The methods used to develop Chapter 6 are based on the extent and challenges of Florida's agribusiness market. Trade sources and secondary numerical, observational, and geographical data characterize the unique hypercommunication needs of agribusinesses in Florida.

Chapter 7 applies the topics beneath it in the Figure 1-1 pyramid to recommend specific Florida hypercommunication markets and agribusiness strategies. The next question is "*How much*" will hypercommunications cost. Actions of both hypercommunication suppliers and agribusiness demanders are based on managerial economics, production economics, marketing strategy, and the management of innovation. Supplier actions also depend on the number and size of firms, the conduct and performance of industry players, and regulation. Leading and up-and-coming service providers are identified in the context of local and regional service availability to help answer "*From whom?*" agribusinesses should buy hypercommunications.

Strategic implications for agribusinesses of hypercommunications will try to follow three maxims to produce useful recommendations. First, everyone is different and every place is different. A multi-million dollar Palm Beach county nursery has different needs and opportunities than a Jackson county peanut grower or a Miami-Dade county vegetable exporter. Therefore, most recommendations will be general and not applicable to every location or every firm. Second, strategic implications will be simple enough to avoid getting lost in technical detail, but broad enough to show the exciting, inter-related, and unpredictable nature of hypercommunications. For example, the choice of a particular telephone system or long-distance carrier can make other hypercommunication services cost more. Finally, hypercommunications are changing rapidly, increasing in complexity. No strategy can possibly keep up. However, specific implications from the economics of hypercommunications help to produce strategies that are resistant to short run change.

Chapter 7 uses numerical and geographical hypercommunication supplier information concerning hypercommunications infrastructure and pricing. Trade sources and secondary data were used to summarize leading service providers, pricing, and regional infrastructure problems in Florida. Specific recommendations were developed for agribusiness hypercommunications based on a fusion of commonly reported business experience, the conceptual pricing model from Chapter 5, and the unique needs identified in Chapter 6. Chapter 7 contains a hypercommunications portfolio decision tree to provide direction for agribusiness communications decisions. Conclusions round out the study at the chapter's end.

CHAPTER 2
FOUNDATIONS OF THE INFORMATION ECONOMY: COMMUNICATION, TECHNOLOGY, AND INFORMATION

> IT (Information Technology) producing industries (i.e. producers of computer and communications hardware, software, and services) . . . play a strategic role in the growth process. Between 1995 and 1998, these IT-producers, while accounting for only about 8 percent of U.S. GDP, contributed on average 35 percent of the nation's real economic growth.
>
> In 1996 and 1997 . . . falling prices in IT-producing industries brought down overall inflation by an average of 0.7 percentage points, contributing to the remarkable ability of the U.S. economy to control inflation and keep interest rates low in a period of historically low unemployment.
>
> IT industries have achieved extraordinary productivity gains. During 1990 to 1997, IT-producing industries experienced robust 10.4 percent average annual growth in Gross Product Originating, or value added, per worker (GPO/W). In the goods-producing sub-group of the IT-producing sector, GPO/W grew at the extraordinary rate of 23.9 percent. As a result, GPO/W for the total private non-farm economy rose at a 1.4 percent rate, despite slow 0.5 percent growth in non-IT-producing industries.
>
> By 2006, almost half of the U.S. workforce will be employed by industries that are either major producers or intensive users of information technology products and services. [United States Department of Commerce, "Executive Summary", *The Emerging Digital Economy II*, June 1999]

Both Chapter 2 and Chapter 3 address *why* networked hypercommunications have originated from the digital information economy just mentioned. Chapter 2 explores three interactive foundations (communication, information, and technology) of the information economy. It ends with examples of a reality gap between technical hype and economic likelihood in the new economy that also depends on the characteristics of networks. However, an understanding of networks, the technical infrastructure and economic infostructure[1] of the information economy, must wait until Chapter 3.

2.1 Introduction: the Continuing Relevance of Economics

Chapter 2 uses economics to produce three foundations of the information economy: communications, technology, and information. As a science, economics is often defined as the study of how society allocates scarce resources to cover humankind's unlimited wants. Economics involves core concepts such as constraints, relative prices, incidence of taxation, symmetry of regulation, and market power. While economics originated as "political economy" in industrial age Europe, the field's core is not out of date in a global information economy. However, the information and service orientation of the international marketplace, combined with business demand for practical inventions amid the hype of high-tech, has led to an increasing diversity of economic thought. It is argued that the times necessitate a re-examination of the artificial boundary between the order of conventional economics and the chaotic complexity of the marketplace [See Giarini and Stahel, 1989, p. 121]. At the same time, Liebowitz and Margolis warn that economists must be wary when:

> So taken are we with these new technologies that we tend to treat these new inventions as *sui generis*, so different in essentials that we cannot even speak of them in the same terms we have used in the past. [Liebowitz and Margolis, 1995, p.1]

To those who view economics as a static, mathematically verbose creature with rare applicability outside academic problems from the industrial age, the hypercommunications market is a trying testing ground for economic theory. It is said in the popular, financial, and trade media that converging communications technologies are so new, fast changing, and different from anything ever known before, that they defy standard economic analysis.

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[1] The word infostructure combines information technology and infrastructure "to acknowledge the importance of analyzing information technologies in concert with the institutional structures needed to obtain, utilize, apply, and sustain them" [IFAS, 1997, p. 3].

According to this view, using economics to study agribusiness hypercommunications is doubly irrelevant. First, some argue that conventional economics has lost its relevance to the information economy. Second, some argue that the information economy is not relevant to agriculture. For example, of the first argument Rawlins writes in 1992:

> Classical economic theory is largely irrelevant to the early stages of a new information industry. Economics assumes that resources are finite and that there is enough time for markets to reach stability. Three things are wrong with this picture: information is not finite, there is no single stable point---there are many, and there is little time to reach stability before there is another major change. [Rawlins, 1992, node 29]

This argument appears to leave room for economics in later stages of the information industry, but an anti-economics vaccine prevents “later” from happening because exponential improvements in synergistic technologies never end; they lead only to new iterations of increasing growth. Perhaps (even in the new information economy) economics could at least serve in a supporting role via capital formation and financial market theories. However, again economics appears to be passé, because while "capital will remain important as a risk softener", knowledge "has become more important to continuous improvement," while financial markets "matter less and less to the economy" [Rawlins, 1992, node29].

On the second irrelevancy, Rawlins, a computer scientist, expresses the popular view that standard economics (a synonym for classical in his writing) is relevant only to sectors such as agriculture that are separate from the information economy.

> Standard economics applies to finite-resource markets like agriculture, mining, utilities, and bulk-goods. Such economics has little to say about information markets like communications, computers, pharmaceuticals, and bioengineering. These markets require a large initial investment for design and tooling, but enormous price reductions with increasing market growth. This growth is further compounded by positive feedback: with increasing market growth the production process gets more efficient, therefore returns increase. [Rawlins, 1992, node 29]

Apparently, conventional economics is useless in the brave new world of the information economy but still matters on the farm or in the food processing plant. Somewhat paradoxically, the information economy's power to alter economics does not make it to the agricultural sector. Presumably, this is because phenomena such as large initial investment in research, price decreases with increasing market growth, and positive feedback occur in Silicon Valley, but not in the San Joaquin Valley. New diagnostic and application techniques (Khanna, 1999) are but one suggestion of how high technology benefits production agriculture. Biotechnology, smart foods, and information about the safety, nutritional, and organic characteristics of food are examples of the importance of knowledge and information to agriculture as a whole. There are many more examples, such as the information and communication needs of horizontally and vertically integrated agribusiness firms.

The discussion of the relevance of standard or conventional economics has ushered in a vocabulary debate within economics itself about what to call the information economy and how to practice a more relevant economics. To some economists and many Wall Street analysts, a new, weightless economy where information goods and knowledge services are produced and traded via technology networks has already replaced the traditional economy. Thus, a “new” economics [Kelly, 1998] or a “weightless” economics [Kwah, 1996, 1997; Coyle, 1997; Cameron, 1998] naturally replaces conventional economics. However, other economists suggest that the information economy is a "network" economy that requires extension of traditional theory to new problems [Shapiro and Varian, 1998].

A body of economic thought is developing on new information age issues ranging from Internet economics to the economic role of technological change. Lamberton writes that economics will have to change.

> The structural and behavioral changes conveyed by the term Information Age require the economist to leave the shelter of his Ouspenkian 'perpetual now'. The economics that survives will no doubt be less amenable to mathematical precision, and its policy counterpart will need to be more tolerant of the role of judgement. [Lamberton, 1996, p. xiv]

However, widespread use of IT and hypercommunications are helping to erase many of the reasons that the market does not correspond to economic theory. Perhaps (armed with better information) it is the economy that is catching up to economic theory, instead of economists (armed with new economics) who are catching up to the economy. Lags and adjustment periods are shorter while information and productivity are enhanced in a communication-driven information economy that better corresponds to theory.

Few would dispute that the view of the typical firm in the information economy has changed from the industrial age economic model. Until recently, many economic problems were cast from the point of view of a factory manager who produced goods in a manufacturing plant. Now, similar and different economic problems are cast from the point of view of an entrepreneur who produces services in an information facility. While many agribusiness problems are much like those of the classical factory manager, agribusiness is increasingly confronted with the high-tech entrepreneur's problems as well.

The technician-entrepreneur at the helm of a high-tech firm needs to respond quickly to a constantly changing environment. As an individual, the entrepreneur's focus may be fixed on technology rather than directly on consumer needs. Every technical detail of an operation may be etched in such a CEO's strategic thought, to the exclusion of tactical ideas about finance, marketing, or hypercommunications. Such an entrepreneur may be striving for greater technical efficiency without adequately considering price, demand, or other economic variables. It is tempting for firms operating in the information economy (agribusinesses included) to imagine that technical expertise alone is most important.

However, firms in the information economy still meet competitors in markets as they did in the industrial age. Furthermore, economic theory typically tries to predict market rather than individual behavior. Interestingly, in markets for all kinds of goods and services worldwide, relative prices still seem to matter. An agribusiness manager may not understand the hypercommunications market, and a hypercommunications entrepreneur may have no clue about

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the citrus market, but both understand their bottom lines. For this reason, in spite of the contention that it cannot keep up with an economy that is increasingly based on communications, technology, and information, economics has hardly lost its relevance. Economics may be more relevant to businesses whose objectives have been forever altered by the new realities of the information economy. New, fast changing, and different as hypercommunications are, old fashioned economics is at work in the form of constraints, relative prices, regulation, profits, costs, and market power within the information economy.

Throughout the information economy, (especially in hypercommunications) the views of engineers and computer scientists have resulted in new technologies, promising infant products, and exponentially growing high technology firms. This chapter will highlight technical aspects of production that are necessary for operation in the information economy. However, economic and marketing perspectives are also covered because non-technical is sometimes overlooked when the discussion centers on new hypercommunication technologies. The economic and marketing perspectives are essential to firms hoping to understand how hypercommunications fits in with existing business strategies. No single view is sufficient.

Chapter 2 opens with three fundamental concepts that provide the origins for the information economy, which serve as the foundation of hypercommunication networks. The first three sections present these concepts: hypercommunications (2.2), technology (2.3) and information (2.4). Rather than use narrow definitions, broad conceptualizations identify the inherently economic context of the information economy and the dominant role of hypercommunications. Then, section 2.5 examines limitations of what has been popularly described as the unlimited cyber frontier. It will be seen that the information economy does not lack constraints. Instead, it has different limits than the traditional manufacturing economy. These economic, behavioral, financial, and technical constraints set the tenor of the information economy and rein in super-optimistic predictions about new hypercommunication services and technologies. Section 2.6 is a short summary. Chapter 3 will cover the unique economic and technical properties of networks, and relate them back to the limitless cyber frontier notion. Taken together, Chapters 2 and 3 provide an answer to *why* hypercommunications are economically and technically important to agribusiness.

2.2 Communication, the First Foundation

In this section and the next two (2.3 and 2.4), the three foundations of the information economy, communication, technology, and information (defined broadly in Table 1-1 in Chapter 1) are conceptualized. Braithwaite (1955, p. 56) describes the process of defining something as being a logical construction of the *definiendum* (thing to be defined) in terms of the meaning of another (the *definiens*). In a highly technical field such as hypercommunications, there is an enormous burden to define terms. For each of the twelve essential terms from Table 1-1, the word or phrase *definiendum* cannot be easily defined with a *definiens* of a few sentences. Terms such as communication, technology, and information require a longer *definiens* because they are conceptually deeper than technical jargon terms or acronyms such as those presented in the glossary.

As Cohen and Nagel pointed out, "the process of clarifying things really involves, or is a part of, the formation of hypotheses as to the nature of things" [Cohen and Nagel, 1934, p.223]. Perspectives from economics, communications, and computer science are spliced with a taxonomic treatment of the hypercommunications jargon. Therefore, useful definitions are conceptualizations that recognize each perspective in the synergistic whole. However, such conceptualizations are longer than telegraph-style definitions.

This section argues that communication is a process that includes models that are hypotheses as to the nature of things. To this end, hypercommunication and communication are defined and conceptualized in five ways. First, a literal definition of hypercommunication is presented (2.2.1). Next, communication is conceptualized through two traditional communication models the interpersonal model and the mass model (2.2.2). Third, a new hypercommunication model is compared with use of the interpersonal and mass models in standard telecommunication (2.2.3). Fourth, a comparison of telecommunication and hypercommunication by elements is made (2.2.4). Fifth, and finally, hypercommunication can also be conceptualized through the taxonomy of hypercommunication services and technologies (2.2.5) that will be used in Chapter 4.

2.2.1 Literal Definition of Hypercommunication

What are hypercommunications, or what is hypercommunication? Alan Stone discusses one "true", or "pure ideal" of hypercommunications in 1997:

> Virtually any person who considers the future agrees that the world is in the process of major social and economic changes and that telecommunications is a driving force of those changes. If that is the case, the study of telecommunications is not simply the examination of one more sector, like pulp and paper, clothing, or automobiles. Nor is public policy for telecommunications just one more branch of public policy studies, like civil rights, airlines, or education. If the experts' projection of the future of telecommunications is a correct one, the sector will be *the* leading one in shaping our social, economic, and political futures. No reasonable person would attempt to predict the future with precision, but we can certainly surmise certain probable trends...the nearly uniform considerations of the experts do portend a dominating future for communications ---domination so extensive that we call the sector hypercommunications. [Stone, 1997, p.1, italics his]

A breakdown of the term hypercommunication into prefix and root gives further clarification. The prefix hyper- is defined as meaning "over, above, more than normal, excessive" [*Webster's New World Dictionary*, college ed., 1960, p.714]. The opposite of hyper- is hypo-, signifying "under, beneath, below, ...less than, subordinated to". Thus, the status quo of communications is hypocommunications, below or beneath the developing world of hypercommunications.

2.2.2 Two Traditional Communication Models: Interpersonal and Mass

Communication signifies the transmission of a message from sender to receiver through a medium, subject to noise. As Figure 2-1 shows, a simple spoken or written message is transmitted one-way through the medium of air to a receiver through noise, represented by a cloud with lightning. The basis for the interpersonal model is from the science of communication, a field that studies interpersonal communication by voice, sign language, writing, gestures, physiology, and body language.

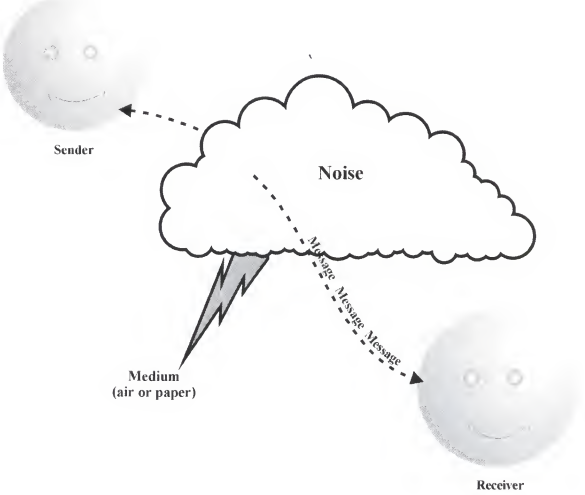

Figure 2-1: Interpersonal communication model.

Historically in interpersonal communication, a message was either spoken or written. It was then delivered in person to a single receiver or group of receivers by voice through the medium of air or by letter, subject to the noise of chattering, interruption, and lack of attention. Interpersonal messages can be one-way or two-way, typically depending on the custom and sociology called for by the setting. For example, oral argument before the Supreme Court of the

United States is two-way if and only if it pleases the Court. A final property of interpersonal messages was that written messages could be preserved verbatim (unlike spoken messages).

As language developed from simple grunts and gestures into Chomsky's modern transformational grammar, messages became more complex. As society became more specialized, so did communication. It took on non-personal forms as well. Storytelling, speechmaking, song, dance, painting, sculpture, and other kinds of expression apparently preceded the written word. Patrons of the arts began to exchange goods in return for various messages of artistic expression or entertainment works. When written, messages became more complex, subject to interpretation, and were necessary for governments, religions, and town commerce. Written messages became valuable enough that markets developed for paid messengers, and later, postage. In 1776, Adam Smith wrote that the postal service was "perhaps the only mercantile project which has been successfully managed by, I believe, every sort of government" [Smith, 1937, p. 770].

The invention of the printing press allowed mass production of written communication so that bibles, other books, newspapers, and magazines became relatively inexpensively produced forms of mass communication. The printing press added a new level of complexity to communication. The interpersonal communication model of Figure 2-1 has become a mass communication model shown in Figure 2-2.

The elements of communication changed when mass written communication became technically feasible. The sender became a specialized communicator such as a publisher, writer, or correspondent who created prepared messages. The message could be duplicated and sent (through the medium of paper or newsprint) to a group of recipients rather than a single person or small group. The receiver in the interpersonal communication model became a group of readers or subscribers. Communication began to be purchased per copy or by subscription. Then, advertising (the paid transmission of a message from a sender to a target group) came to exist alongside editorial writing. Because of the high cost of entry into publishing, there were now inherently more receivers (readers) than there were senders (publishers). The roles of editor, correspondent, reporter, and scientific writer as gatekeepers were established at this time.

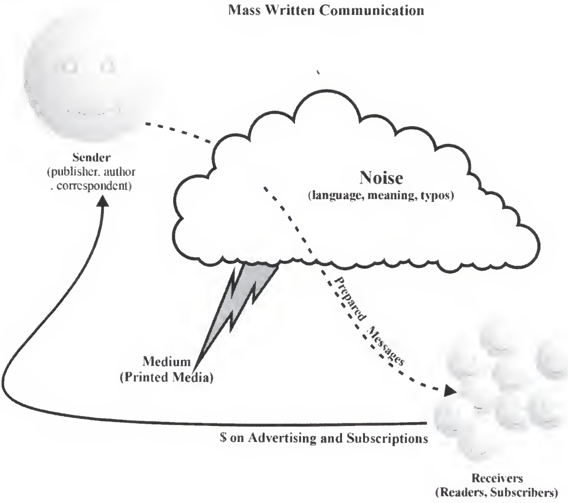

Figure 2-2: Mass communication model.

2.2.3 The Hypercommunication Model Succeeds Telecommunication

As technology developed, telecommunication evolved. The prefix *tele* comes from the Greek where it meant "far off" or "distant". Telecommunication differs from both interpersonal communication and mass written communication by the medium and form of the message. However, telecommunication continued to follow either the mass communication model *or* the interpersonal model depending on the medium used.

The first form of telecommunication was telegraph, followed by telephone, radio, and finally, television. The telegraph, telephone, and two-way radio were each closely modeled after the interpersonal model. Television and broadcast radio followed the mass communications model insofar as they were unidirectional, mass-produced, and subject to gatekeepers. While telecommunications has come to have a wider definition than telegraph, telephone, and television, new technological realities have spawned hypercommunication. Unlike telecommunication, hypercommunication is a blend of both the communication models shown in Figure 2-1 and 2-2.

Open interconnection and networking (which came originally from data communication) are the enabling technologies of hypercommunication. The new hypercommunication model shown in Figure 2-3 is a synergistic combination of Figures 2-1 and 2-2, resulting in an array of new communication elements. In Figure 2-3, the interpersonal model, the mass model, and telecommunication are combined with data communication.

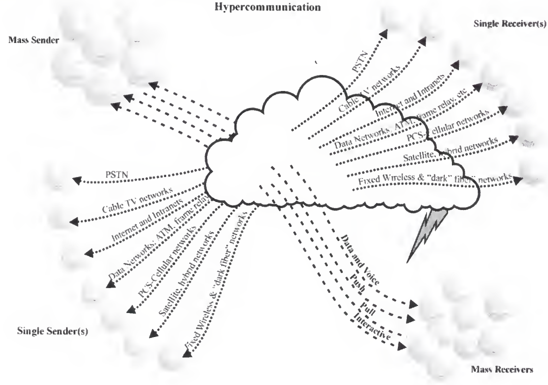

Figure 2-3: The hypercommunication model is a synergistic mesh of networks combining new communication elements with the mass and interpersonal models.

Additionally, positive network externalities are enhanced through open standards interconnection to yield a single mesh structure, a hypercommunication network. Telecommunications (already an ingredient which is the product of other, separate ingredients) is of course a major part of the hypercommunications pie. However, the finished product, hypercommunication is unlike telecommunication because it is an open system featuring unique positive (and negative) synergies among the networked parts.

There are three important ways the generalized hypercommunications model of Figure 2-3 differs from its predecessor models. First, hypercommunication is based on a common, interconnected network that consists of the full set of old transmission networks along with some new high technology networks. Second, hypercommunication allows for both old and new kinds of messages to be sent and received over that common network. In general, the networks and message types mesh so that each message type can travel from sender to receiver though one or all of the networks. Third, hypercommunication is based on new technologies that have redefined senders, receivers, distance, and noise so that the social and economic relationships of communication are synergistically more powerful than before.

The first way hypercommunication differs from its predecessor models is that it is a unified mesh of networks rather than a set of separate unconnected networks. In Figure 2-3, the hypercommunication model translates the old concept of communications media into a new concept of an open, interconnected communication networked medium carrying many message types. Previously disparate networks are shown by the lines moving from the lower left to the upper left of the diagram. These include the PSTN (Public Switched Telephone Network), cable TV networks, the Internet and other data networks, together with a variety of wireless networks (broadcast TV and radio, cellular, etc.). Before the advent of the hypercommunication model, each network was a separate medium generally based on the interpersonal or mass model. Both technology and deregulation now allow these previously separate networks to interconnect so that interpersonal and mass communication blends with the Internet and other new technologies. The hypercommunication model enables single senders to transmit messages (of any type) to single or mass receivers through the integrated mesh structure. Similarly, hypercommunication allows mass senders to transmit content to an audience of mass receivers or to transmit customized interactive content to individual receivers.

A second difference between the hypercommunication model and its predecessors is it permits many message types to be created and carried through the mesh of networks. In Figure 2-3, message types are shown going from the upper left to lower right. Message types may be generally based on content (voice or data) or directionality (push, pull, or interactive). Voice messages include two-way telephone calls, conference calls, automatic calling, audio webcasting, voice mail, and voice e-mail. Data messages include numbers, text, binary computer code, video, and graphics. The voice-data distinction itself is a vestige of a fading distinction between analog and digital networks. Voice communication traveled on analog networks and data traveled on digital networks[2]. In reality, currently almost all voice messages are transmitted digitally as data.

Push messages include text and binary streams, graphics, and other content automatically sent to a single receiver or (more typically) to groups of receivers. Push messages may be voice, video, facsimile, text, graphics, or a mix. Push messages include subscribed webcasts, e-mail auto-responses, news crawls, quotation services, or they can be annoying automatic teledialing, junk faxes, and unwanted spam. Video streams include webcasting, TV and cable programming, live video auctions, video conferencing, and webcam transmissions. Pull messages are one-way, often invisible to communication users. Examples of pull messages include caller ID, call blocking and Internet cookies. Interactive messages are two-way and "conversational" in nature. Examples include interactive websites, telephone conversations, and video conferencing.[3]

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[2] In Chapter 4, the important distinction between digitization of transmission signal and digitization of the communication content is discussed. To avoid confusion, the explanation is reserved until then.

A third way the hypercommunication model differs from its predecessors is that it involves new roles for both senders and receivers, along with a host of new technological and economic characteristics. Technological details are best left until Chapter 3, but consider a few key economic differences between hypercommunications markets and telecommunications markets. Begin by noting the corners of Figure 2-3 and the box at the bottom: mass senders, mass receivers, single senders, single receivers, and Intranets. Mass senders and mass receivers are terms used to symbolize the role of the mass communication model in hypercommunication. Single senders and receivers symbolize the role of the interpersonal communication model in hypercommunication. The concept of an Intranet symbolizes communication within an organization. Hypercommunications use the same network for mass and interpersonal communicators.

For single senders and receivers, the hypercommunication model of Figure 2-3 offers several differences from telecommunication. First, hypercommunication rests on an interconnected mesh network so that telephone customers, cable TV customers, and ISP customers have new communication choices that do not depend on the monopolistic structure of the telecommunications carrier market. Second, the term "single" (synonymous with small) provides less of a barrier to access and entry under the hypercommunication model due to deregulation, interconnection, and the role of the Internet. The fixed and variable costs of interpersonal and mass communication have fallen dramatically in the integrated hypercommunications network. Distance and geographical boundaries are also less of a barrier.

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[3] The technical nature of synchronization, full duplex or half duplex transmission, message primitives, and latency are covered later in Chapters 3 and 4.

For the cost of a computer and peripherals, small firms and single individuals can create and transmit hypercommunications messages on a global scale because costs are dramatically lower.

For mass senders and mass receivers, the hypercommunication model differs from telecommunication in several ways. First, there are more types of messages. Second, there are more kinds of receivers (receiver as a device and an audience member) than under traditional telecommunication because the network interconnects previously separate media. Third, distance is less of a barrier to communications owing to digitization. Fourth, the direction, timing, and latency of hypercommunications transmission are more variable than those of traditional telecommunications transmission are. Fifth, because it is based on computer hardware, software, and the digitization of information, the hypercommunications model permits senders and receivers to store, copy, summarize, and re-use information in an unprecedented way.

2.2.4 Comparison of Telecommunication with Hypercommunication

A definition of communication by elements underscores both the immense potential of hypercommunication and the inherent differences between telecommunication and hypercommunication. Legally, there are over 100 definitions of communication in current use according to Ploman (1982), so while any definition will be imperfect, more detail is necessary. A reasonably detailed definition of modern communication covers nine elements in Table 2-1:

> Communication is an (A) *information processing activity or exchange process* involving: (B) *signal transmission* of (C) *message types* (text, voice, video, data, content), (D) from a *sender or senders* through (E) *space* and (F) *time* (real time, live streaming, and delayed streaming), using a (G) *transmission network* to (H) a *receiver or receivers* or an audience (one person, several people, millions of people), (I) *subject to noise* and *incompatible standards*.

The exchange of information among people, organizations, or devices is an information processing activity or exchange (A) requiring that information (to be defined in 2.4) be input, patterned, processed, and coded into message form. Technology (to be defined in 2.3) permits element (B) transmission (or delivery) of hypercommunication signals using the PSTN, the Internet and other computer networks, wireless networks, or broadcasting networks.

Table 2-1: Elements of hypercommunication compared to telecommunication.

Element	Telecommunication	Hypercommunication
(A) Information processing or exchange activity	Information may be filtered by a gatekeeper, processed mentally.	Gatekeepers less important, mental processing more important, computers and devices process and filter information.
(B) Signal transmission	Traditional analog content via digital or analog signal.	Digitized content transmitted via digital signal.
(C) Message types (text, voice, video, data)	Separate interpersonal and mass media, ability to record and re-send messages.	Choice of any message type, more latitude for recording and re-sending, less privacy and security.
(D) Sender or senders	Emphasis on a single sender.	Emphasis on group or network senders, technology can change sender's anonymity.
(E) Space	Distant communication possible, but cost depends on distance.	Distant communication technically simpler, cost less dependent on distance, infrastructure required.
(F) Time (real time, live, delayed streaming)	Little choice as to time or timing, some ability to record.	More choice as to time (of sending and receipt) and timing (latency, delay).
(G) Transmission network	Separate networks for separate services.	Separate technologies used to create a mesh of networks with interconnected services.
H. Audience (one person, several people, millions of people)	Typically either a mass audience or a single receiver.	Sender can choose audience size from a single recipient to highly targeted small audience.
I. Noise and incompatible standards.	Interference, static, cross talk, jamming.	Incompatible software and hardware standards and protocols, delay and congestion.

The variety of message types (C) has already been introduced. With both telecommunication and hypercommunication, a given message may be stored, copied, and re-used, while in other cases copyright laws, technology itself, or other barriers prevent storage, copying, or re-use. Hypercommunication makes copying, changing, and retransmission of messages easier and cheaper than was possible with traditional telecommunication. Technical material in Chapters 3 and 4 will highlight the greater range of message types hypercommunication offers over telecommunication.

The sender (D) may be a person, business, organization, or government, if the sender's identity is known at all by the audience. Technology and deregulation enable a larger number of senders to inexpensively hypercommunicate than to telecommunicate. Open protocols and inter-networking allow a larger number of senders to join a larger common network than is possible with telecommunication.

Pricing of telecommunication traditionally depended on whether the mass model or interpersonal model was followed. Interpersonal telecommunication (such as telephone) was often priced based on distance through space (E). Mass telecommunication was supported by advertising and subscription. Improved technologies allow messages to travel farther through space over a digital networked infrastructure at a relatively lower cost.

Unlike telecommunication, hypercommunication offers choices concerning communications time and timing (F). Delivery can be instant (real-time), delayed, or archived. A message can be re-sent until the recipient is available or the sender can be notified automatically when the message is received.

The differences between telecommunication networks and the hypercommunication network (G) have been introduced already. Unlike the radio and television networks of telecommunications, no single organization could "own" the entire hypercommunication network. This is because architecture is open and the emphasis is on interconnection. Chapters 3 and 4 will discuss many technical reasons that the hypercommunication network differs from telecommunication networks.

The audience (H) may consist of one person or many, with message delivery being push or pull, instant or delayed, simultaneous or non-simultaneous. The audience may pay for the message through direct subscription, indirectly though exposure to advertising, by carrier access costs, or not at all.

Noise (I) has always meant electrical interference, static, crosstalk, or other barriers to clearly hearing, seeing, or understanding a message. Now, it may also include a host of hardware and software factors such as network failures, congestion, and operator error at both ends that prevent delivery of messages on time, or at all. Finally, incompatibility of standards is the ultimate form of noise because communication is prevented from occurring at all, or is considerably delayed ---so that the marginal cost outweighs the marginal benefit.

2.2.5 Specific Hypercommunication Services and Technologies

An operational definition of the hypercommunications sector is given in Chapter 4 where specific categories of services and technologies are presented. These (now partially separate) telecommunication and data communication sub-markets are converging into a hypercommunications sector. In the four hypercommunications sub-markets, services must be separated from the wireline and wireless technologies that provide them, sometimes a difficult task. Hypercommunication services are provided to customers by carriers or content providers using technologies that are often invisible to customers.

The first sub-market includes traditional telephony services, local and long-distance calling, basic signaling (dial tone and ringing), coupled with traditional telecommunications technologies (switching, circuits, and local loops). In the past, these services had been closely regulated monopolies, but the 1996 TCA (Telecommunications Act) and other legislation has encouraged deregulation and competition. Real-time voice conversations messages occur between sender and receiver in traditional telephony or POTS (Plain Old Telephone Service), as traditional service is known in technical jargon. A technical overview of the POTS PSTN will be found in Chapter 3.

The second sub-market includes newer enhanced landline and wireless telecommunications services. Services in this category range from caller ID, call waiting, and PCS to elaborate CTI (Computer Telephony Integration) systems offering agribusinesses hundreds of options of connecting telephones and computers. These services are supported by enabling software and hardware transport technologies such as AIN, DS-100 switching, and SS7 signaling, and electromagnetic carrier waves. PBXs (Private Branch Exchanges) and other computer and telephone hardware and software must be purchased by the agribusiness to take advantage of many enhanced services. Enhanced services were originally developed by local telephone monopolies or ILECs (Incumbent Local Exchange Carriers) but now are also available from competing ALECs (Alternative Local Exchange Carriers) authorized under deregulation. Enhanced services are based on existing traditional services and are interconnected with traditional service networks (especially the PSTN). Enhanced services have been less regulated than their traditional counterparts, but the TCA affects these services almost as profoundly. Enhanced services and technologies send voice, signaling data, limited text, and paging messages.

The third sub-market includes private data communication and networking services such as: Intranets, frame relay, ATM (Asynchronous Transfer Mode), and SMDS (Switched Multimegabit Data Service). Computer and networking technologies such as routers, cabling, and other CPE (Customer Premises Equipment) must be purchased by agribusinesses using private data services. Bandwidth and equipment are available from ILECs, but because this category is largely unregulated, services are also available from ALECs and ISPs. Furthermore, firms in the conduit and hardware businesses often strategically partner with hypercommunication carriers to enable one-stop shopping. This is the only hypercommunication sub-market almost entirely made up of business customers. Currently, most messages are digital data communications, including the exchange of text and binary files. However, technical convergence is so rapid that private networks are becoming flexible enough to include all message types. Chapter 3 contains technical and economic foundations of computer networking.

The fourth hypercommunication sub-market is the broad Internet sector. This area includes Internet access and bandwidth, e-commerce, and Internet QOS (Quality of Service). The Internet has increased awareness of transmission variables (such as speed, capacity, and delay) in every hypercommunications category. The Internet differs from private networking because of circuit ownership, protocols, and ubiquity. Internet access is a more open architecture than private networking services because a portion of the loop is through an ISP connection to a public backbone rather than exclusively dedicated for private use. Internet technologies substantially overlap other hypercommunications categories to include IP telephony, live two-way Internet video, and webcasting. Messages types carried by the Internet include familiar forms such as e-mail, web page content, and file transfers. Internet messages also include less familiar forms like voicemail, Internet telephony, live video feeds, interactive chatting and cyber shopping. Many connections to the Internet are still made via narrow-band modems via the PSTN to ISPs. However, data transmission technologies used in private networking (frame relay, ATM, DSL, and broadband) provide greater speed and convenience for Internet access, increasing availability and lowering cost. The Internet has successfully resisted most regulation.

All four sub-markets rely on a variety of wireline and wireless transmission technologies to operate. Additionally, protocols and standards are needed to help hypercommunications firms and their customers avoid the deadweight loss of searching for technical specifications to enable widespread interconnection. Protocols and standards (such as TCP/IP and SS7 signaling) evolve from scientific agreement, governmental edict, or from industry bodies and competition. Protocols and standards allow the broadest possible market to be formed as well as allowing pricing and definition of market services.

Three points conclude this section on economic conceptualizations of hypercommunications. First, hypercommunications categories are asymmetrically regulated. There are various federal, state, and local government agencies (such as the FCC and FPSC, Florida Public Service Commission) with regulatory control. These regulators affect what services will be available, where, at what price, and with what kinds of taxation or subsidy. However, regulation does not apply uniformly across every hypercommunications category thereby distorting individual categories and the entire hypercommunications sector. The telephone and Cable TV markets (even with recent deregulation) are far more regulated than the Internet access market for example. Government is also involved with anti-trust enforcement and legislation covering market structure, conduct, and performance in hypercommunications as in other industries. The recent joint action of the federal Department of Justice and numerous state Attorney Generals against Microsoft is a current example, while the breakup of AT&T's Bell System by the federal courts is an historical example. Chapter 5 is dedicated to policy and regulation.

Second, hypercommunication can often be quantified for economic and technical analysis. Hypercommunication can be characterized by traffic shape, capacity, delay, speed, and other quantitative analyses. Chapter 3 covers the technical and economic foundations of networks, the source of these measures. Chapter 4 covers the bandwidth, data rate, throughput, and a number of other quantitative measures known as QOS (Quality of Service) variables that are unique to hypercommunication.

The third environmental factor, the qualitative side to hypercommunication, is important economically and can be easily forgotten if hypercommunication is viewed from a pure engineering perspective. A particular message may be considered invasive or undesirable even when flawlessly sent and received in physical terms. The concepts of a message, medium, noise, attention, and a receiver are likely to be looked at differently by a network engineer's technical objectives than from a business, economics, or communications orientation. Additionally, hypercommunication has important social implications with economic repercussions. Issues of security, fraud, privacy, and freedom of paid and non-paid speech will have to be addressed for markets to function.

Now that hypercommunication has been conceptualized as the first foundation of the information economy, it is time to conceptualize the other two: technology (2.3) and information (2.4).

2.3 Technology, the Second Foundation

Technology, the second of three foundations of the information economy, is an important catalyst for the entire information economy, not just for the hypercommunication sector. Using economic and technical literature, this section defines and examines technology *generally* to better understand the economic roles it plays in the information economy. Coverage of specific *network* technologies (and related economic precepts) will be found in Chapter 3. Specific *hypercommunication* technologies are discussed in Chapter 4.

Technology, (from the Greek, *technologia*), means: "1) the science or study of the practical or industrial arts, 2) the terms used in science, art, etc. 3) applied science." [*Webster's New World Dictionary*, college ed., 1960, p. 1496] To a firm, technology "is a basic determinant of a company's competitive position" [Ashton and Klavans, 1997, p. 8]. Technology includes current product features and performance, "the capacity, yield, quality, and efficiency of ... production processes". Technology also "helps determine the unit costs of making and delivering products and the nature of capital investments", while serving as "the source of new products and processes for future growth". Finally, technology is "a valuable intelligence focus" that "can be a direct source of business revenue" [Ashton and Klavans, 1997, p. 8]. Used strategically by business, technology has "the potential to create or destroy entire markets or industries in a short time" [Ashton and Klavans, 1997, pp. 8-9]. More broadly, others argue that technology comprises all problem-solving activities including how people and organizations learn, and the stock and flow of knowledge [Cimoli and Dosi, 1994].

The organization of section 2.3 follows the roles played in the information economy by technology as identified in Table 2-2. First, it is important to understand how sources of technological change are best identified and modeled in economics. There are four chief schools of thought or research agendas: induced innovation, evolutionary theory[4], path dependence, and endogenous growth [Ruttan, 1996; Homer-Dixon, 1995]. Ruttan argues that while each "...agenda has contributed substantial insight into the generation and choice of new technology...", the lack of co-operation and fresh results has caused the foursome to reach a "dead-end" [Ruttan, 1996, p. 2].

2.3.1 Research Agendas in the Economics of Technological Change

Differing views about the sources and economic implications of technological change are responsible for considerable differences in economic thought among the four agendas. Differences range from minor adjustments in conventional microtheory in the induced innovation school to the "paradigm shift" of the evolutionary agenda, to the completely "new" economics demanded by path dependence theorists. The endogenous growth agenda has brought macroeconomic thought into the microeconomics of technology. Auerswald *et al.* argued in 1998, "...macroeconomics is ahead of its microeconomic foundations" because of the endogenous growth agenda's macroeconomic models of technological change in production. The term mesoeconomics refers to the application of macroeconomic endogenous growth factors of production such as human capital, technical knowledge, and other non-conventional inputs and outputs to microeconomics.

The first agenda, the induced innovation literature, argues that technical change is a "process driven by change in the economic environment in which the firm ... finds itself" [Ruttan, 1996, p. 1]. According to Christian, "Models of induced innovation describe the relationship between" production (summarized by factor-market conditions and "the evolution of the production processes actually used") and "the demand for the finished product" [Christian,

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[4] Arrow (1995) argues that the evolutionary agenda is a "point of view", not a theory [Ruttan, 1996].

1993, p. 1]. The relative scarcity of resources and changes in relative prices induce or guide technological change under this view.

Work in induced innovation has concentrated in several areas. One analytical strain consists of macroeconomically oriented growth theoretic models [Kennedy, 1964, 1966; Samuelson, 1965]. These models were developed to examine stable shares of aggregate factors, in spite of intensive substitution of capital for labor in the U.S. economy. The demand-pull strain holds that changes in market demand lead to increases in the supply of knowledge and technology. Micro and macro studies of demand-pull focused on how the location and timing of invention and innovation were stimulated by demand [Griliches, 1957, 1958; Schmookler 1962, 1966; Lucas, 1967]. A supply-push orientation holds that changes in the supply of knowledge lead to shifts in the demand for technology.

Rounding out the induced innovation work is a fourth strain, factor-induced technical change, based on Hicks' idea that "a change in the relative prices of factors of production is itself a spur to innovation and inventions..." [Hicks, 1932, p.124]. Along with Ahmad's [1966] paper, the Hicksian ideal that relative prices matter launched iterations of microeconomic models. Economic historians (Habakkuk, 1962; Uselding, 1972; David, 1975; Olmstead, 1993) and agricultural economists (Hayami and Ruttan, 1970, 1985; Thirtle and Ruttan, 1987; Olmstead and Rhode, 1998) have worked in this fourth area. Microeconomic models were used to show empirically that exogenous changes in relative prices induced innovation, moving firms away from costly inputs toward relatively cheaper ones.

The second agenda, the evolutionary perspective, stems from the recognition by Alchian (1950) and other economists that the behavior and objectives of firms are more uncertain and complicated than received theory allows due to the inevitability of mistakes. The genesis of this approach is credited to Schumpeter's later (1943) recognition that synergistic feedback between R&D and innovation could allow certain firms to influence demand [Freeman, Clark, and Soete, 1982]. At the firm level, “the crucial element is full recognition of the trial-and-*error* character of the innovation process” [Nelson, Winter, Schuette, 1976, p. 91].

Evolutionary models use a "black box" behavioral theory of the firm and its larger operating environment. The “black box” represents the firm's decision objectives and rules in a search for technological modifications that begins in the neighborhood of existing technologies. Alterations in conventional microtheory (bounded rationality among heterogeneous agents), collective interaction, and continuously appearing novelty create an economic world of emergent, unstable dynamic phenomena [Dosi, 1997]. The firm itself relies on historical "routines" and "decision rules" rather than "orthodox" profit maximization or other global objective functions [Nelson and Winter, 1982, p.14]. Cimoli and Della Giusta argue that "the standard statistical exercise of fitting some production function" could still be done under the evolutionary approach. However, "the exercise would obscure rather than illuminate the underlying links between technical change and output growth" [Cimoli and Della Giusta, 1998, p. 16].

The third agenda, the path dependence model arises from the idea that technological change depends on network effects and sequential paths of development [David, 1975; Arthur *et al.*, 1983]. Under this view, many candidate technologies interact with random events in the early history of a new technology. The result is a winning technology (not necessarily the optimal one) that locks in an economic path, down which future technological iterations march. Under conventional thought, well-behaved technologies have diminishing marginal returns in individual factors, constant returns to scale for all factors together, and stable equilibria.

Unlike conventional convex technologies, under path dependent theory the networked products, organizations, and markets can produce multiple equilibria, globally increasing returns to scale, and disobey the "law" of decreasing marginal returns. Increasing returns "act to magnify chance events as adoptions take place, so that *ex-ante* knowledge of adopters' preferences and the technologies' possibilities may not suffice to predict the 'market outcome' " [Arthur, 1989, p. 116]. Path dependencies can "drive the adoption process", causing domination by "a technology that has inferior long-run potential" [Arthur, 1989, p. 117]. Contributions from the path dependent school to network economics are covered in Chapter 3.

The fourth agenda originates in the endogenous growth macroeconomics literature as advanced by Romer (1986, 1990). Ideas about the non-convexity of technology from endogenous growth have seeped into micro thought through ideas such as "knowledge is assumed to be an input in production that has increasing marginal productivity" [Romer, 1986, p.1002]. Nobel Laureate Robert Solow demonstrated in the 1950's that knowledge was a motor for economic growth [Solow, 1956, 1957]. Based on Solow's results, a "narrow" version of endogenous growth holds that the main source of productivity increase (output per worker or dollar of capital) depends on the progress of science and private sector R&D expenditures. A "broad" version posits an "indirect relationship between technological improvement and economic activity" based on learning by doing or reorganization of the production process [DeLong, 1997, p.12].

Table 2-2 shows the roles that technology plays in the information economy. The coverage given each role differs, emphasizing those where hypercommunication and agribusiness are most influenced. Each of the four research agendas is used in the discussion. However, conventional economic models are used to establish each topic.

The discussion is separated into roles because technology is often used with only one of these meanings in mind. When economists, engineers, or agribusinesses discuss the role of technology in a firm or industry, they are often discussing different concepts. Robert Solow admitted the truth of this among economists in 1967, "...the economic theory of production usually takes for granted the 'engineering' relationships between the inputs and outputs and goes from there" [Solow, 1967, p. 26]. However, "new" economists argue that analyses of technology require that technical and economic relationships in the industry and within the firm be considered in addition to interactions among them.

Table 2-2: Roles played by technology in the information economy.

Sec.	Role	Topics
2.3.2	Production: technical aspects	MPP and MRTS, technical factor interdependence, technical factor substitutability, returns to scale and scale neutrality, returns to scope
2.3.3	Production: economic aspects	Returns to size vs. returns to scale and size neutrality, non-homothetic technologies and modifications in production economics, economic interdependence of factors, factor bias and augmentation
2.3.4	Managerial	Internal, allocative, and dynamic efficiency, operational, tactical, and strategic flexibility, other dimensions (scope and system) measurement of technical change
2.3.5	Supply	Decreasing cost industries, technology treadmill, technology as public good (technology spillovers)
2.3.6	Demand	Demand shifts, diffusion of innovation, pro-competitive, anti-competitive, and neutral effects
2.3.7	Technology-Information linkage	Composite functional relationship between technology and information

2.3.2 Technology and Production: Five Technical Aspects of Invention

The first major role played by technology in the information economy is the technical efficiency of a new production technology. In conventional economics, a firm's production function encloses what Varian calls the "production set", or "set of all possible combinations of inputs and outputs that are technologically feasible" [Varian, 1987, p.310-311]. Beattie and Taylor define a production function as:

> ...a quantitative or mathematical description of various technical possibilities faced by a firm. The production function gives the maximum output(s) in physical terms for each level of the inputs in physical terms. [Beattie and Taylor, 1985, p.3]

However, a discussion of the technical and engineering roles of technology in the information economy (even in the realm of agribusiness) requires a broader perspective than the production function of conventional economics for three reasons. First, new technologies (IT, networks, and biotechnologies) often do not behave along traditional economic lines. Second, the conventional view of the agribusiness firm differs from the emerging reality of the transgenic[5] firm (Baarda, 1999) because implicit and explicit vertical and horizontal integration takes unconventional forms. Third, the economic and technical literature offers many helpful new approaches.

One of the benefits of conventional economics is that, when practiced well, it can simplify complex systems into elegant models. A variety of details (covered in this chapter and the next) such as time compression, information overload, communication, information, and network externalities have received specialized treatment in the economics literature. However, such important tangencies to mainline economic thought lack wide audiences. The results are hard for agribusinesses to use unless presented in a recognizable form such as the production function. Importantly, while some arguments concerning the usefulness or existence of the production function will be presented, the production function (when considered more broadly than it often has been) retains enormous value in analyzing technology's economic and engineering roles. Perhaps the value stems from the fact that the concept behind a production function is understood by economists, farmers, and engineers. Possibly, the production function's continuing utility comes from being a common baseline against which the roles of new technologies can be compared.

2.3.2.1 Technical and economic distinction

The distinction between technology's direct role in altering the technical side of production (covered in this section) and technology's indirect role in altering the economics of production (to be covered next in section 2.3.3) could not be more important. That distinction is often at the heart of the disparate philosophies of the engineer and the economist regarding the impact of technology. Understanding this economic-technical distinction makes economics more consistent with the information economy in three ways.

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[5] A transgenic organism is one that has been transformed because technology has brought new DNA into its genome. Biotechnology also created the transgenic firm, a recombinant legal organism that is organizationally altered because of the new marketing arrangements needed to retain property rights to patented plant and animal forms. The notion of the transgenic firm can be extended to any system or network of firms who bond together to protect other kinds of intellectual property such as information.

First, on a micro level, it shows that Schumpeter's early distinction between innovation and invention need not be a demarcation criterion for economics [Schumpeter, 1934, Vol. 1, p. 84]. The early Schumpeterian view was that invention (unless it directly produced innovation) was an "economically irrelevant" experimentation in technical feasibility. Innovation (which did not require invention) included economic feasibility and economic efficiency in addition to mere technical efficiency. Path dependent and evolutionary economists argue that such an arbitrary distinction has lead conventional economics to faulty analyses of weightless technologies, production teams, and inter-firm alliances of the information economy.

Ironically, Schumpeter's early (1934) thought is sometimes used by conventional economists as a demarcation criterion while his later (1943) chapter on how capitalism's "process of creative destruction" was "evolutionary" germinated the sprouts of the evolutionary school. It has been pointed out that the irony arises from the fact Schumpeter himself edged away from Marshall's view of technical change as continuous, later believing that technological change often occurred in discrete, revolutionary bursts [Moss, 1982, p.3].

The diversity of innovation (according to Schumpeter) heightens the irony that some economists would prevent the consideration of discrete or bursty "inventive" technological changes in favor of mathematically well-behaved, continuous "innovation". Rensman notes (1996) that Schumpeter enumerated five kinds of technological innovations:

> 1) a new good or new quality of good, 2) a new method of production, 3) opening of a new market, 4) discovery of new resources or intermediates, and 5) a new organizational form. [Rensman, 1996, p.1]

Some of these can hardly be considered continuous phenomena.

To bring invention into the domain of economics along with innovation, "new" economists argue that there are six kinds of technological *inventions*: the five *innovations* mentioned above, plus basic or theoretical research. The first five are goal-oriented activities, with clear economic incentives. Both self-employed individual inventors (the rule in Marshall's day) and organizationally employed R&D teams (part of the modern R&D function) engage in such goal-oriented invention. However, the sixth, pure theoretical research is often undertaken with an epistemic value or evolutionary organizational value in mind rather than (or in addition to) conventional objectives. The tendency to exclude "inventive" production from economics ignores the employment of inputs in the production of research and invention and ignores how Schumpeter defined technological innovation.

On this basis, Perrin (1990) suggests that there is a difference between "pre-adoption" and "post-adoption" research into the economics of technology. Homer-Dixon adds that the economic-technical distinction includes ingenuity (the generation of practical ideas) and the dissemination of productive ideas [Homer-Dixon, 1995, p. 587]. Thus, part of the rationale behind an economic-technical distinction in production aligns with Schumpeter's early invention-innovation idea and part relies on the technical and inventive stages within an overall process from idea generation to dissemination.

A second way understanding the economic-technical distinction improves the consistency of economics with the information economy is by highlighting the apparent fragility of two notions. First, economic efficiency requires mathematical determinism and integrability. Second, economic efficiency always guarantees technical efficiency. A deterministic worldview, if enforced through well-behaved primal or dual technologies, can rule out entire classes of economically relevant technologies. When economic efficiency is defined solely in neat, tautological fashion by the mathematics of static, structurally fixed markets, (where identical firms maximize profits or minimize costs given well-behaved single commodity output production functions and perfect certainty), it implies technical efficiency. Indeed, the generality and elegance of the duality approach simplify empirical work while providing what Silberberg calls theoretical "soundness" [Silberberg, 1990, p. 285]. However, as Pope and others have recognized, "not all problems seem to be capable of being studied using duality" [Pope, 1982, p. 350].

Multi-product production, non-conventional inputs, network effects, and ever-shorter decision periods (all a result of new technologies) can make economics appear inconsistent with the times. The evolutionary and path dependent agendas question whether standard production and cost functions are useful in analyzing many kinds of technological change to begin with. They contend that economic concepts of the firm and production need to be broad enough mathematically and technically to acknowledge the changes that IT, hypercommunications, and biotechnology bring. This is underscored by Williamson: "The firm as production function needs to make way for the firm as governance structure if the ramifications of internal organization are to be accurately assessed." [Williamson, 1981, p.1539; quoted by Cotterill, 1987, p. 107]

However, because of advances in computer technology, conventional mathematical constructs and their successors may become even more useful in understanding core technical-economic distinctions. Even if duality and conventional mathematical economics are passé, as some "new" economists argue, [Kelly, 1994] a theoretical cocoon with equal or greater elegance would seem necessary to replace them. Until this occurs, modifications in the general idea of a production function (and optimization of profit, cost, or something else) may give economics a view of the economic-technical distinction that better reflects non-conventional technologies and network effects. Indeed, along with new views of the firms and supply chains that constitute markets, mathematical extensions of conventional economic models may be more important than ever. In 1963, Morgenstern saw the importance to economic problem solving that technologies of the "new" economy (computers and combinatorial economic software) would have. He noted that technology itself would "continuously generate new problems of a mathematical nature" to bring the unlimited penetration of mathematics into economics. This led him to note the impossibility of "any 'limits' to the use of mathematics" (in economics) [Morgenstern, 1963, p. 29].

A third way that understanding the economic-technical distinction makes economics more consistent with the information economy is by revealing a broader view of efficiency than that of the economist or engineer alone. According to Kevin Kelly, Peter Drucker has argued that the productivity problem for each worker in the industrial economy was how to do his job right (most efficiently). Kelly argues that in the new economy, "productivity is the wrong thing to care about" because the "task for each worker is not 'how to do his job right', but 'what is the right job to do?' " [Kelly, 1997, p.14]. Evolutionary and path dependent theorists would argue that standard economic theory (from which production functions are taken) is so simplistic that "it does violence to reality" [Arthur, 1990, p.92]. Under Kelly's twelfth rule[6] for the new economy, the law of inefficiencies, he writes: "Wasting time and being inefficient are the way to discovery." [Kelly, 1997, p. 14]

Yet new ways of looking at technology within economics are (as Arthur notes when discussing increasing returns) "not intended to destroy the standard theory", but to "complement it" [Arthur, 1996, p. 3]. The decision rules and routines of the evolutionary theorists "are close conceptual relatives of production 'techniques'" [Nelson and Winter, 1982, p.14]. In an e-business setting, such as amazon.com for example, the routines that Nelson and Winter say "replace the production function" presumably include such technological efficiencies as high-tech commerce servers and software [Nelson and Winter, 1982, p.14]. Amazon.com may be a highly efficient firm in a technical sense, but as of January 2000, it has yet to make a profit.[7] The question of whether a firm or industry can be economically but not technically efficient requires a modified view of production that considers the technical-economic distinction with a broad view of efficiency.

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[6] In 1998, Kelly reduced the twelve laws to ten. The "law of inefficiencies" became "opportunities before efficiencies". [Kelly, 1998]

[7] Models of monoperiodic loss minimization or multi-period net present value can be used to argue that amazon.com really is profit maximizing (though it is losing money). However, these extensions of conventional theory do not disprove the argument that path dependencies, satisficing, or other goal-oriented evolutionary routines may be at work in addition (or instead).

2.3.2.2 Conventional production: simple technology, MPP, MRTS

The simplicity of the conventional production function enables understandable first-order comparisons of technical and economic efficiency to be made. In the conventional perspective, improved technology helps a producer to produce more output with the same amount of inputs to become more *technically efficient*. It is another matter to say whether firms that adopt progressive technologies are also *economically efficient*. Each kind of efficiency can be thought of as a matter of degree in applied work where "revealed efficiency" is used to compare "overall" efficiencies among firms [Paris, 1991, pp. 287-306].

The production function "identifies the maximum quantity of a commodity that can be produced *per time period* by each specific combination of inputs" [Browning and Browning, 1989, p. 168, italics mine]. The concept of decision period or length of run is central to the analysis. Using Hicks' two inputs, capital (K) and labor (L), Persky names four decision periods (VSR, SR, LR, VLR) that are important to engineers, economists, and agribusinesses alike:

> In the very short run (or market period), the quantities of both inputs are fixed. In other words, K and L are both parameters.
>
> In the short run, the quantity of one input is fixed, and the quantity of the other input can be varied. In other words, either K is a parameter or L is a parameter. We usually take K as the parameter.
>
> In the long run, the quantities of both inputs can be varied.
>
> In the very long run, the quantities of both inputs can be varied, and the production function can change. This case represents technological improvement. [Persky, 1983, p. 146, underlining in original]

The evolutionary and path dependent schools would debate Persky's assessment that the VLR is the only place technological change can occur.

Additionally, in a weightless information and knowledge economy, no VSR exists in some cases because the production plan varies by the minute. Later in the chapter (2.5), the concept of time compression due to technological progress in hypercommunication and information processing will be discussed. As will be emphasized then, IT is responsible for greater flexibility in varying inputs as well as for increasingly shorter decision periods. Therefore, the cases of VSR and VLR are less apart in time than they once were. Not incidentally, inexpensive high-speed hypercommunications allow the instantaneous transmission of large amounts of information to anywhere reached by a high-speed infrastructure, permitting (but not guaranteeing) faster planning and decision making.

It might appear as though production agriculture might not benefit from time compression due to new technology the way other industries do. Crop seasons and animal cycles create relatively inflexible decision periods. However, intellectual property, communication, and information are weightless inputs whose share makes up an increasing proportion of total factor mix in agriculture. Indeed, biotechnologies and high-tech crop monitoring allow even production agriculture to achieve an unprecedented degree of control and flexibility over factors. Furthermore, technologies are appearing that are able to time compress agricultural production processes as well. One example is the case of biotech "super pigs" that grow forty percent faster to larger weights than before, using less feed and other inputs while decreasing piglet death rates[8] [Hardin, 1999; Associated Press, 12/7/99].

Consider how the conventional production function could vary due to a new technology. Graphically, the technical effect on production of a technological change can easily be shown through the production function in the single output, single input case. Figure 2-4 shows six cases of how a new technology can alter the technical side of production. Depicted is a generalized monoperiodic production function. Assume that the firm has perfect certainty[9] as it compares the old and new production processes before the next production period.

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[8] A Florida newspaper headline squealed that the 21st century might become the "Century of the pig!", while the AP wire story lead was that "Someday, hogs may not have to eat like pigs."

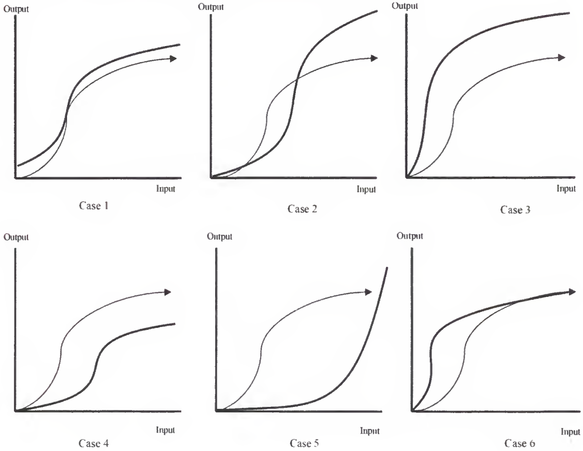


Figure 2-4: Six cases of technology's effect on production, one variable input example.

The baseline for each case is a thin line (representing an identical base production function) ending with an arrow. In each case, a new technology's influence on production is shown by a bold line. Without more information than the production function alone, the probable economic behavior of a firm cannot be established. Assume that the only change between cases is technology as embodied in the production function.

---

[9] Assumptions such as this one may or may not be robust in the chaotic path dependent world or the behavioral black boxes of the evolutionary firm. For an example of a probabilistic production function where information is imperfect see Phillips (1997).

Case one shows a new production function that is a parallel shift of production under the old technology. The MPPs (Marginal Physical Products) are identical and the only difference is a constant additional quantity of output at all input levels resulting from the new technology. By converting to the new technology, more units of output will be produced for the same amount of input, regardless of whether a small amount of input or a large amount is used.[10] The fixed quantity of output produced by the new technology appears to be scale neutral (does not depend on how much input is used).

Case two depicts a new technology that produces less output for a given amount of input up until a point. After that point, more can be produced by the new technology than under the old one. Case two favors larger scales of operation. In case three the new technology is always and everywhere able to produce more output (given the same amount of input) than under the old technology. Case three is scale neutral, favoring adoption of the new technology at any scale of operation.

In case four the new technology always and everywhere produces less output given the same amount of input than under the old technology. Economically, it is hard to imagine a firm that would replace an old technology with a new technology that always produced less. The fifth case depicts a new technology that is better than the old technology only at a relatively large operational scale. Note that the new technology underperforms the old one until the MPP of the old is approximately zero, where the output of the new technology races above the old one. Case six shows that adoption of the new technology holds only for lower levels of inputs. Once the MPP of the old technology approaches zero, the two production functions are virtually identical. In this case, the new technology would tend to favor a smaller scale than the old one.

---

[10] Assume case one is undefined at the origin, so no production occurs without at least some input.

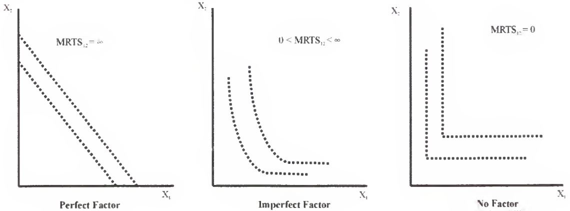
A slightly more general mathematical treatment brings in two inputs, so that production with the new technology may be better compared to the base-case production function. Now, four core concepts of technical production are considered: technical substitutability among factors (2.3.2.3), technical factor interdependence and separability (2.3.2.4), average and marginal returns to scale (2.3.2.5), and returns to scope (2.3.2.6).

2.3.2.3 Technical factor substitutability

The effect of a technical change on factor substitutability is an important technical aspect of production. However, it can be measured in many ways. Beattie and Taylor admit that factor substitutability can be a misnomer. "Economists' use of the term, factor substitutability, to refer to isoquant patterns is a bit unfortunate…it only means that isoquants are convex to the origin…" [Beattie and Taylor, 1985, p. 29]. Convexity can result from chemical interaction or other synergies (such as network externalities) between factors so that it is not necessarily true that one factor actually "substitutes" for another.

Technical factor substitutability hinges on the relationship among inputs needed to produce a particular output level. Consider a two input production function $y = f(x_1, x_2)$, let x_1 and x_2 be physical units of a factor of production. The MPP of x_1 is simply the first partial derivative, $MPP_1 = \frac{\partial f(x_1, x_2)}{\partial x_1} = f_1$, likewise the MPP of x_2 is $MPP_2 = \frac{\partial f(x_1, x_2)}{\partial x_2} = f_2$. The MRTS of x_1 for x_2 ($MRTS_{12}$) is derived from the total differential of the production function, $dy = f_1 dx_1 + f_2 dx_2$. If dy = 0 as it must along an isoquant, then $0 = f_1 dx_1 + f_2 dx_2$. The slope of any isoquant is given by $\frac{dx_2}{dx_1} = -\frac{f_1}{f_2}$. The $MRTS_{12}$ is the absolute value of the ratio of MPPs, $\frac{f_1}{f_2}$. The $MRTS_{12}$ tells how many more units of x_1 would be needed to hold output constant, while taking away one unit of x_2. The MRTS and isoquant curvature are related to the technical substitutability of factors as Figure 2-5 illustrates.

Technological change can be brought in to the production function more explicitly. In a conventional approach a three input production function, $y = f(x_1, x_2.T)$ could use T as time (a proxy for technological change). A positive rate of technical change given by $\tau = \frac{\partial \ln f(x_1, x_2, T)}{\partial T}$ would assume that all changes in output over time that are not the result of varying x_1 or x_2 are due to progressive technical change. However, as Solow points out, " . . . there is no reason why T should not change by discrete jumps, or from place to place, or from entrepreneur to entrepreneur" [Solow, 1967, p. 28]. This specification implicitly treats technological change as an exogenous residual.



Perfect Factor Substitutability

Imperfect Factor Substitutability

No Factor Substitutability

Figure 2-5: Isoquant curvature and technical factor substitutability.

Alternatively, a production function could include inputs of a particular technology as explicit endogenous factors rather than as an exogenous technological change residual. The path dependent, evolutionary, and endogenous growth schools use such approaches to model non-conventional technological inputs such as information, knowledge, or communication in a production process. The idea is that technology can change along with other inputs so that the VLR-LR distinction is different from the conventional case. The approach is best applied to multi-output cases.

T could be physical units (or a vector of parameters) representing a technology. Then, a particular technology's effect on other inputs could be evaluated individually and jointly. However, the generality of such an alternative view of the production function can violate conventional assumptions such as perfect certainty, continuous differentiability, monotonicity, and concavity. Relaxing these assumptions can lead to intractable empirical results.

No graph can show every way that technical factor substitutability can be altered by technological change. This is since, as Chambers notes, "there is no correct answer or measure of the degree of substitutability between any two inputs" [Chambers, 1984, Ch.1, p. 18]. In an n-input case, the problem concerns the percentage change in input x_i that would result from a one-percent change in the amount of input x_j.

Several unit-free measures of the degree of substitutability among inputs exist including the direct elasticity of substitution, the Allen partial elasticity of substitution, the Samuelson total elasticity of substitution, and the Morishima elasticity of substitution. The direct elasticity is a short-run measure of substitutability between input i with input j, holding all other inputs fixed, while the Samulelson elasticity measures the substitutability of input i against all other inputs. The Allen elasticity of substitution is a measure of relative input change along an isoquant since it measures the elasticity of the ratio (x_1/x_2) with respect to the $MRTS_{12}$ with output held constant. Diverse elasticities of substitution complicate comparisons of how a technological change affects input substitutability.

2.3.2.4 Technical factor interdependence, separability

The next technical concept of production, technical factor interdependence, is another way technological change can influence production. Economists often do not differentiate between technical factor *substitutability* (where output is held constant) and technical factor *interdependence* (where output is not held constant). Beattie and Taylor state that "Two factors are technically independent if the MPP of one is not altered as the quantity of the other is changed." [Beattie and Taylor, 1985, pp. 32-33] In the two input case there are three technical factor interdependencies given the production function $y = f(x_1, x_2)$. Each depends on continuous second cross partial derivatives as follows:

$$\frac{\partial^2 y}{\partial x_1 \partial x_2} \equiv \frac{\partial}{\partial x_1}\left(\frac{\partial y}{\partial x_2}\right) \equiv f_{12} = f_{21}$$
$$\frac{\partial^2 y}{\partial x_2 \partial x_1} \equiv \frac{\partial}{\partial x_2}\left(\frac{\partial y}{\partial x_1}\right) \equiv f_{21} = f_{12}$$

Factors are technically independent when $f_{12}= 0$, so that the MPP of one factor is not affected by changes in the physical amount of the other. The technically complementary case occurs if the cross partial $f_{12} >0$. In the complementary case, increasing x_1 raises the MPP of x_2. The case of technically competitive inputs occurs when $f_{12}<0$. There, increasing x_1 reduces the MPP productivity of x_2.

The technological change could be biased toward one factor or be Hicks neutral. In the (Hicksian) factor neutral case, a new technology leads to increased output without changing factor proportions. If the $MRTS_{12}$ is independent of T, then technical change is factor-neutral. Isoquants retain the same curvature and position, but represent larger values over time because both factors in the same combination are able to produce more output. Hicksian factor-neutral technical change requires that, given a fixed factor proportion, $\frac{\partial}{\partial T}(\frac{MPP_1}{MPP_2}) = 0$. In other words, T is separable from both x_1 and x_2 in production, $y = f[\Phi(x_1, x_2), T]$. With Hicks-biased technical change, a non-homothetic isoquant shift occurs so that technology will change the relative contribution of inputs to production. Isoquant curvature remains the same, but positions differ. This will be covered further during the discussion of the economics of production and factor neutrality (2.3.3.2).

If the efficiency or effectiveness of a particular input alone increases with T, the technical change is said to be factor augmenting. Rather than consider if technical change alters factor proportions, this approach looks at how technological changes alter the elasticity of substitution and differential rates of input quality. For example, the education of farmers may be land augmenting if land in the hand of an educated farmer is capable of wider technical possibilities. The technological change (due to education, but measured by the passage of time) becomes embodied[11] in land but not in other inputs. In such a case, a measure of the rate of technical change can be decomposed into the individual rates of change per input (a scale expansion effect) and a pure shift effect [Chambers, 1984, Ch.5, p.7]. This is shown graphically in Figure 2-12 in (2.3.3.2).

Technical factor interdependence is important to the tenets of network economics because of the inherent complementarity of network hardware and software. The path dependent school is based on the technical independence of competing pathways of technological development. Chapter 3 will cover economic and technical foundations of communications networks in further detail.

2.3.2.5 Returns to scale and scale neutrality of technology

Returns to scale (isoquant spacing) is the third technical aspect of production. Returns to scale can be global or local, and be constant, increasing, or decreasing. According to Silberberg, "constant returns to scale...means that if each factor is increased by the same proportion, output will increase by a like proportion" [Silberberg, 1990, p. 93] Mathematically, given the two input production function $y = f(x_1, x_2)$ and a constant proportion t, constant returns to scale occur when $f(tx_1, tx_2) \equiv tf(x_1, x_2)$. Increasing returns to scale occur when $f(tx_1, tx_2) > tf(x_1, x_2)$, while decreasing returns to scale occur when $f(tx_1, tx_2) < tf(x_1, x_2)$.

---

[11] According to Nadiri, "quality improvement in a factor should not be considered equivalent to the embodiment effect. The latter refers only to quality improvement associated with vintage of capital or cohort of labor. For example, productivity increases due to sex and race characteristics (at a point in time) are *not* part of the embodiment effect, while improvements due to age and education *are* part of it" [Nadiri, 1970, p. 1143].

Figure 2-6 compares increasing and decreasing returns to scale. Isoquants become more closely spaced as inputs are proportionally increased under decreasing returns to scale. Under increasing returns to scale, isoquants become spaced farther apart as inputs are proportionally increased.

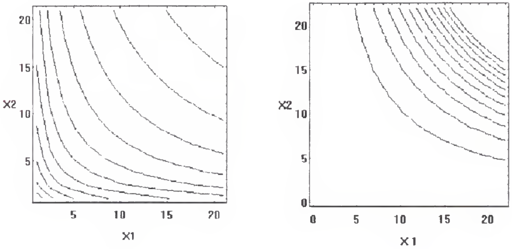


Figure 2-6: Returns to scale: decreasing (right) and increasing (left).

Often, an important adjective (such as marginal or average) is left out of the description, leaving a certain "untidiness" in the use of the term "returns to scale" [Beattie and Taylor, 1985, p. 47]. The existence of a distinction between marginal and average returns to scale depends on whether the function is homogenous or non-homogenous,[12] or (stated another way) fixed proportions or variable proportions. Consider the production function $y = f(x_1, x_2.)$. Suppose again that each factor is increased by a like proportion, t. The function is homogenous of degree r if $f[(tx_1), (tx_2)] \equiv t^r f(x_1, x_2)$ where r is a constant and t any positive real number.

---

[12] Strictly speaking, the distinction between marginal and average returns to scale depends on the ordinal property of homotheticity (whether a function is monotonically transformable into a homogenous function) rather than the cardinal property of homogeneity. However, as Simon and Blume note: "we care a great deal about the number that a production function assigns to any isoquant". Therefore, " . . . the distinction between cardinal and ordinal is of no concern when we are speaking about production functions" [Simon and Blume, 1994, p. 499]. Nonetheless, in keeping with general use in the literature, the term homothetic technology will be used.

Homogenous functions (of which r=1 is the special case of linearly homogenous) will not require any distinction between marginal and average returns to scale because "both average and marginal returns *everywhere* increase, *everywhere* decrease, or *everywhere* remain constant" [Beattie and Taylor, 1985, p. 47]. All such homogenous functions exhibit constant proportional returns so that the distinction between average and marginal returns to scale is unnecessary. The degree of homogeneity, r, shows the returns to scale that the function exhibits so that if $r > 1$ increasing returns to scale exist, $r < 1$ decreasing returns to scale exist, and $r = 1$ constant returns to scale exist. Technologies are scale neutral if constant returns to scale exist, larger scales are favored if increasing returns to scale exist, and smaller scales occur under decreasing returns to scale. Just as in the single input case discussed along with Figure 2-4, such scale economies depend on economic variables and function homotheticity before their economic implications can be considered.

Returns to scale and non-homotheticity are important to "new" economists, network economics, and the path dependent view. One way homotheticity can arise is through non-conventional, non-rival inputs such as technical designs. Romer provides a classic example:

> . . . if F(A,X) represents a production process that depends on [an exhaustive list of] rival inputs X and non-rival inputs A, then by a replication argument, it follows that $F(A, \lambda X) = \lambda F(A,X)$. . . . If A is productive as well, it follows that F cannot be a concave function because $F(\lambda A, \lambda X) > \lambda F(A,X)$. [Romer, 1990, p. S76]

Romer's original focus was on the macroeconomy, so the argument "neglects integer problems that may be relevant for a firm that gets stuck between n and n+1 plants", but it is motivated by a simple example [Romer, 1990, p. S76]. A firm can invest 10,000 hours of time to produce an engineering design (non-rival input) for a 20MB disk drive. If it builds a $10 million factory and hires 100 employees, it can produce 100,000 drives (two trillion MB) of storage per year. By replicating the rival inputs (factory and employees), the output doubles to reach four trillion MB. If the firm had used 20,000 hours of engineering time (which would have lead to a design for a 30MB disk drive) that could be made by the same factory and workers. If it doubles all inputs, the 20,000-hour design, two factories, and 200 employees produce 6 trillion MB, three times the original amount [Romer, 1990, pp. 254-255].

Examples such as this are used (along with arguments about network effects) to suggest modifications to production economics that would make it more consistent with the technologies and organizations of the information economy. The picture is incomplete when erroneous conclusions are drawn about the technical or economic implications (alone or together) of technology. More discussion will be found in sub-section 2.3.3 (when returns to scale and returns to size are compared), as well as in Chapter 3 when network economics is covered.

2.3.2.6 Returns to scope

The theory of multiple product production offers another concept, returns to scope, that is important to technology's technical role in production as well. Factors in multiple product production are of two types: allocable or non-allocable. In the allocable case, units used to produce one product are distinguishable from units of the same factor used to produce another product. In the non-allocable case, the amount of each factor used to produce different products cannot be separated. Multiple products may be produced jointly (perhaps as by-products such as beef and hides) or non-jointly. Beattie and Taylor [1985, pp. 179-184] and Henderson and Quandt [1980, pp. 92-103] present basic treatments, while Farë, 1995 has a detailed discussion.

When it is technically more efficient to produce two or more products together, a technology that offers increasing returns to scope would be one where doubling inputs would yield more than double the outputs. In a multi-product agribusiness, it is not difficult to imagine either hypercommunications or information as examples of non-allocable factors (or indirect factors) for which increasing returns to scope would be theoretically likely. Hypercommunication technologies enable multiple products to use the infrastructure that previously delivered a single product, so that overall production becomes technically and economically more efficient. The ability to place a fax machine on a telephone line shared with voice calls is an early example. A more recent example is that of ADSL (Asymmetric Digital Subscriber Line) services. The same copper telephone line is conditioned so that Internet browsing, telephoning, and faxing occur simultaneously through more efficient packing of each kind of signal in the wire circuit.

2.3.3 Technology and Production: Four Topics in the Economics of Production

Until now, emphasis has been on the first role played by technology in the information economy, the technical aspects of production without considering the second role, the economics of production. Before considering five topics in the economics of production, it is important to understand how new technologies have created a new economics. Since new versions of theory are created at a slower rate than new versions of high technology are, the received view in economics is itself under pressure to keep up. Such technological pressures mean that the lagging economic principles of production can be overshadowed by headlines of new technological possibilities. A technical, economics-free view of new technology has become a fashionable norm in popular discussions and shoestring analyses of the high-tech businesses and industries that make up the information economy.

In agribusiness as well, production's technical side may overshadow the economic side for several reasons. First, new technologies seem to be introduced almost daily, changing almost every aspect of distribution, sales, and processing-production. These include direct biotech inputs such as new genetic seeds and disease-resistant plant varieties as well as new product technologies that create new outputs such as smart foods (nutraceuticals). Indirect inputs such as IT and hypercommunications are another class of technologies, designed to help agribusinesses market, manage, or finance operations better. The rapidity of technological progress makes it hard for management to track new technologies that will best help a particular operation, necessitating improved communications and highly trained technical staff. Second, it is hard for managers to follow (much less to filter) the claims of technically trained purveyors of new technology. This can cause either the rejection of a worthy and profitable new technology or the acceptance of an unnecessary and costly one due to managerial discomfort with the technical dimensions. Either way, the decision may be based more on what competitors do than on economic analysis. Third, public perceptions of possible dangers of new agricultural technologies (especially biotechnologies) must also be understood.

Importantly, a new technology may be misconstrued by economists because of their own unfamiliarity with the scientific[13] and technical details, or because conventional economic theory may not admit the *existence* of that technology. Unless a particular technology is "well-behaved" (consists of an axiomatically constructed production possibility set and separable input requirement set), conventional economic theory cannot do its best job of analysis. According to the evolutionary and path dependent schools, conventional economics is ignoring the technologies of the information economy.

This tendency of economists to restrict technologies within well-behaved boundaries may be especially true for many technologies involved in the information agribusiness economy. IT, biotechnology, and hypercommunication technologies are often considered poorly behaved. In 1985, *Business Week* called economists an “endangered species” because their abstract views of technology omit scientific and business reality. Giarini and Stahel support this, saying: “This is highlighted in e.g. the definition of economists as people who look at something in practice and ask if it will work in theory.” [Giarini and Stahel, 1989, p. 121]

However, as the four topics in this sub-section will show, economics is reasonably robust to rule breaking technologies. This observation assumes economists will avoid the mistake of trusting in a "current economic model" that "refers to scientific principles which science has long ago abandoned" [Giarini and Stahel, 1992, p. 5]. The emergence of a new definition of returns to scale from network economics along with work on non-conventional factors and nascent production technologies in the evolutionary school [Auerswald, *et. al.*, 1998] form the basis for the modified approach.

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[13] See Musser (1997), "Why Economists Should Talk to Scientists and What They Should Ask?"

2.3.3.1 Returns to size, size neutrality of technological change

The difference between returns to scale and returns to size is at the core of the technical-economic distinction within production. The difference (when applicable) will establish returns to size as an economic outcome of technological change in production. It is also an important reason the four research agendas used by economists to study technological change disagree. Beattie and Taylor explain the difference:

> Returns to size, unlike returns to scale, is not exclusively a technical issue...return to scale has to do with expansion of output in response to an expansion of all factors in fixed proportion---a movement along a factor beam. Returns to size has to do with a proportional change in output as factors are expanded in least-cost or expansion path proportions.... only for the special case of constant proportional returns will the expansion path be a factor beam. Since combinations of factors in least-cost proportion are assumed in deriving the cost functions of the firm, it is actually this concept rather than that of returns to scale that is most important in the theory of firm growth or optimum firm size. Return to size has to do with the economic notion of what is happening (decreasing, constant, or increasing) to costs (average variable cost and marginal cost) as output is expanded.... the terminology is sometimes inappropriately used interchangeably. [Beattie and Taylor, 1985, p. 52-53]

The expansion path shows "the long-run increases in . . . operations made possible by increases in the budget" under cost minimization [Mahanty, 1980, p. 181]. The output expansion path comes from simultaneously solving the first order conditions of cost minimization and then solving the relation $\frac{p_1}{p_2} = \frac{MPP_1(x_1^C, x_2^C)}{MPP_2(x_1^C, x_2^C)}$ for x^c_2, the cost minimizing level of x_2. Figure 2-7 is one way to illustrate how returns to scale and size can differ by showing two kinds of output expansion paths.

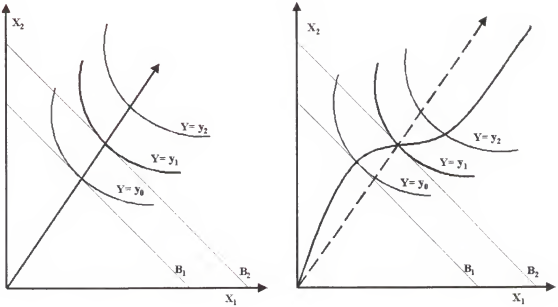

Figure 2-7: Returns to scale and returns to size differ when (as shown in the right panel) a technology does not exhibit a linear output expansion path.

The left panel of Figure 2-7 depicts a homogenous production function with constant returns to scale, where a ray from the origin is both output expansion path and factor beam. Along the ray, the proportion contributed to total product by each factor (factor share) is constant. Simultaneously, as output rises from y_0 to y_1 to y_2, this constant proportion also represents the cost minimizing input bundle. Though the non-homothetic production function in the right panel of Figure 2-7 also exhibits constant returns to scale, the cost minimizing input bundle differs from a constant proportion ray (factor beam) as output is increased. The proportion a cost minimizing firm will allocate to factor two is greater at output y_0 than at y_2. Stated differently, the MRTS in the neighborhood of the optimum varies as output varies. A non-homothetic technology can have increasing, decreasing, or constant returns to scale (globally or locally) and have either a linear or non-linear output expansion path.

With a homothetic technology, a particular return to scale (shown by isoquant spacing) automatically implies a particular return to size (shown by average unit cost as output rises). This mapping from technical to economic is shown in Figures 2-8 through 2-10. Figure 2-8 shows decreasing returns to scale on the left. Since a homothetic technology produced it, the economic implication is a diseconomy of size (decreasing returns to size) as shown in the right panel. Note that the LRAC (Long Run Average Cost) increases as output increases, meaning that the technology favors a smaller size of operation.

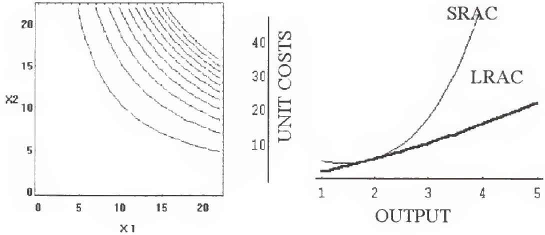

Figure 2-8: For homothetic technologies, decreasing returns to scale implies diseconomies of size

The SRAC (Short Run Average Cost) reaches a minimum at approximately two units, suggesting an optimal SR operational size for a cost minimizer. If a new homothetic technology with decreasing returns to scale moved isoquants inward, the economic implications would be seen through a downward movement of LRAC and a downward (rightward) movement of SRAC.

In Figure 2-9, constant returns to scale implies a constant LRAC (constant returns to size), so that the technology is neutral as to size. However, SRAC is minimized at approximately five units suggesting an optimal least cost size of operation in the SR. In Figure 2-10, increasing returns to scale implies economies of scale and, therefore, increasing returns to size. Both SRAC and LRAC continue to fall as output increases.

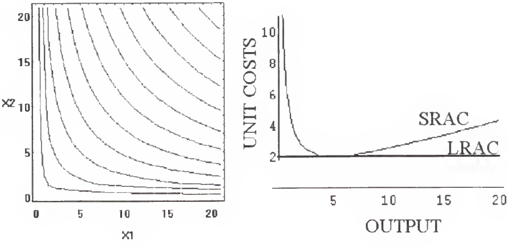

Figure 2-9: For homothetic technologies, constant returns to scale implies constant returns to size.

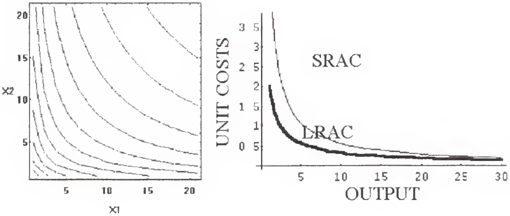

Figure 2-10: For homothetic technologies, increasing returns to scale implies economies of size.

A before and after comparison of a homothetic technological change for either technology from Figure 2-9 or 2-10 could be made (using either economic cost or technical production data). The result could suggest whether technological change was biased as to size (or equivalently, scale). The beauty of the economic dual approach is that by using only the cost data, a before and after technology comparison could be made.

However, returns to scale can be increasing, decreasing, or constant for non-homothetic production functions as well. While non-homothetic technologies may exhibit isoquant spacing similar to the left panels of Figures 2-8 through 2-10, they do not imply the same mapping of economic returns to size. The term increasing returns to scale is used sometimes in network economic literature as a synonym for increasing returns to size; even the assumption of automatic homotheticity is not made for biotechnologies, information technologies, and service producing technologies. This creates a problem if economists hope to re-create the technology using the cost function data or if production engineers wish to understand the economic implications of a non-homothetic technology. The implications of non-homothetic technologies on returns to size will be revisited in 2.3.3.4 with a graphical example.

2.3.3.2 Factor neutrality, factor augmentation, and technical change

There are two other economic effects of technology in production. The first, factor neutrality, assesses whether a technological change is biased in favor of a particular factor or factors or is instead Hicks neutral. Here, the question centers on whether technical change alters relative factor shares through the MRTS [Nadiri, 1970]. Then there is the question of whether the new technology is also (or instead) factor augmenting, where the efficiency or effectiveness of a particular input alone increases due to technological change. Rather than considering if the MRTS is independent of technical change, this approach looks at how technological changes affect the elasticity of substitution and differential rates of embodiment (changes in input quality). These ideas were originally brought up as technical effects of production in 2.3.2.4 during the discussion of technical factor interdependence and separability.

Changes in factor shares to due to changes in a homothetic technology can be shown by graphically comparing output expansion paths. Figure 2-11 shows how a technological change alters isoquant position and the optimal amount of each factor hired given a constant budget. In each case in Figure 2-11, a new technology has led to a new output Q_2 that exceeds the output Q_1 under the old technology. The new, higher Q_2 isoquant is shown superimposed on the old, lower

Q_1 isoquant. Each panel differs by how technological change affects the producer's optimal input ratio, which is constant for all output levels.

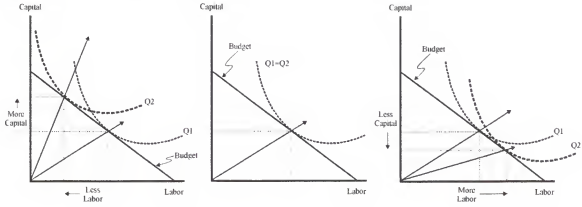

Figure 2-11: Output expansion paths compared among labor saving, capital saving, and neutral technologies.

The left-hand panel of Figure 2-11 shows a capital using (labor saving) innovation increasing the optimal input ratio (K/R) so that an increase in output (Q_2>Q_1) can occur with the same budget. More capital is used than before the new technology, but less labor. The right-hand panel shows that a labor using (capital saving) innovation decreases (K/R). Less capital is hired but more labor used in the new technology than the old one, but output is again higher for the same budget. In the center panel, output rises, but the new technology has the same optimal ratio. In this case, the new technology is factor neutral.

Normally, changes in equilibria can be demonstrated through comparative statics. However, the efficacy of comparative statics depends on model specifications, and whether technological changes occur gradually and continuously or suddenly and discretely. As an example, technological change can be decomposed graphically (in a simple case) as shown in Figure 2-12.

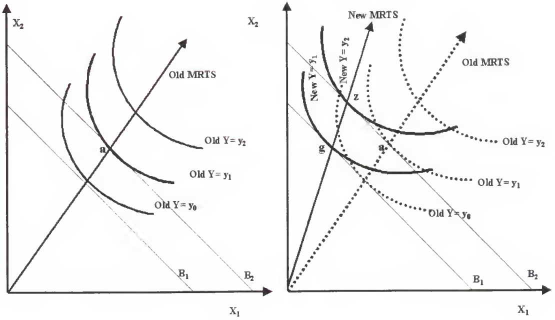

Figure 2-12: Graphical decomposition of the effects of technological change.

The before technological change panel, on the left, shows three isoquants ($y_0<y_1<y_2$) and two isocost lines $B_1<B_2$ and a solid linear output expansion path. In the left panel, the firm can afford B_2 and wishes to minimize the cost of production, so that it ends up producing y_1 units of output at point **a**. The right panel depicts a factor augmenting technological change. It also has isocosts B_1 and B_2 (since prices are assumed fixed), but a new output expansion path and a new set of isoquants (the new y_1 equals old y_1 in output units). The old output expansion path and isoquants are shown as dotted lines, establishing the location of point **a**. Note that unlike Figure 2-11, both isoquant curvature and position have been altered by the technical change in Figure 2-12.

An important question is precisely how the firm's behavior might change due to the technological change. The problem could be defined as how the firm moves from point **a** to point **z**, the new cost minimizing bundle. It is helpful to understand what has (and has not) changed in Figure 2-12 due to the technical change. The first change is that the input combinations that create a given level of output depicted by the isoquant positions have changed though the quantity levels have not. The second change is in the curvature of the isoquants. The third change is that the $MRTS_{12}$ has risen, meaning that it takes more units of x_1 to hold output constant (while taking away one unit of x_2) than it did before the technical change. While prices and isocost curves are identical, it is as if there has been a fourth change (from y_0 to y_1) because the firm could maintain the original output level at y_1 and pocket the savings [Nadiri, 1970].

The order in which the changes might happen is an entirely different situation. Movement from **a** to point **z** represents the change in output level and isoquant position, the change in isoquant curvature, and the change in $MRTS_{12}$ (constant isocost). Movement from **a** to point **g** shows the changes in isocost, isoquant curvature, and $MRTS_{12}$ (constant output). Movement from **g** to **z** shows the change in output and isocost, with constant MRTS and isoquant curvature. The change in MRTS is called a bias or shift effect. The change in output (from isoquants of same curvature to another) is called an output effect, and movement from one isoquant curvature to another while keeping the same output level) is called a scale expansion effect.

2.3.3.3 Economic factor interdependence

A fifth topic in the economic aspects of technology in production is the economic interdependence of factors. Beattie and Taylor (1985) distinguish the economic interdependence of factors from the technical interdependence of factors. Recall that in the discussion of technical factor interdependence, output was not held constant. Now, under economic factor interdependence, the concern is what happens to the amount of a factor hired as the prices of other factors change, also when output is not held constant.[14] "A factor of production x_1, is *economically* complementary to, independent of, or competitive with another factor x_2, if an increase in r_2 decreases, does not affect, or increases the use of x_1." [Beattie and Taylor, 1985, p. 123]

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[14] Under "perfect competition in all markets, economic and technical interdependence of factors are synonymous concepts" according to Beattie and Taylor, differing in "magnitude but not in sign" [Beattie and Taylor, 1985, p. 124]. However, maintaining separate uses underscores the difference between the computer engineer's view and the economist's, not only under perfect competition, but also under other market structures.

Consider a single output case with two factors of production. Suppose a factor demand for the input x_1 is calculated from simultaneous solution of the first-order conditions for profit maximization. The factor demand equation which satisfied the first-order and second-order conditions for profit maximization might be $x_1^* = x_1^*(r_1, r_2, p)$. Where x_1^* is the profit maximizing amount of factor 1 hired, r_1 is the input price of x_1 r_2 is the input price of x_2, and p is the output price.

That is if $\frac{\partial x_1^*}{\partial r_2} < 0$ then x_1 and x_2 are *economically complementary*. If instead $\frac{\partial x_1^*}{\partial r_2} = 0$, then x_1 and x_2 are *economically independent*, while if $\frac{\partial x_1^*}{\partial r_2} > 0$, then x_1 and x_2 are *economically competitive*. Demand elasticities or the derivatives themselves could be compared before and after the introduction of a new technology. The comparison could reveal essential economic effects of the new technology without the precise form of the production function.

The examples from Figures 2-11 and 2-12 could be altered to show the economic effect of a new technology in three ways. The effect of a new technology could be direct, indirect, or both from the firm's viewpoint. Technology could directly change the production surface or technology could indirectly change the relative prices of the inputs (and hence the amounts of factors hired), or both.

In the first case, a factor biased, factor augmenting, or joint effect could directly change the shape of the firm's production function. In the second case, the least cost input combination (but not proportion) needed to produce a fixed output level could change indirectly due to a technological change. This could arise from changes in the relative prices of the inputs because of their use with the new technology in other industries and firms.

Assuming the economics adequately capture the technology, the economic approach provides better information than a purely technical approach does about the role of technology in information economy production. However, the economic implications of new technologies could be missed if economists misdiagnose a new technology because the technical aspects are either not understood or inadmissible. However, a review of the literature suggests this problem is being aggressively pursued through modifications in the economics of production (covered next) and through broader managerial economics approaches covered in 2.3.4.

2.3.3.4 Modifications to production economics

One view of conventional theory is that the economics of production drives the technology of production. By obtaining costs as a function of output level and input prices, it is often assumed that the indirect production function may be recovered. This is mathematically true of homothetic technologies and useful in empirical analyses, but alternative schools argue that it has become a direction of causality instead of an approach to measurement.

Alternative research agendas seek to whittle modifications into the economics of production using technologies of the information economy, rather than jam the square pegs of non-conventional inputs, outputs, and firms into round holes left for them by industrial age economics. Under alternative approaches, many problems in production economics depend on the technology of production more than technology depends on economics.

Three examples of how new technologies are driving modifications in the economics of production are discussed. First, six general modifications to the economics of production proposed by alternative schools are examined. Second, a modified definition of increasing returns to scale from the network economics field is introduced and analyzed. Third, these two areas are followed by a graphical example of a non-homothetic technology.

First, new technology is driving modifications in the economics of production so it fits the information age rather than the industrial age. Critics of standard economics argue that homotheticity (and other assumptions regarding production) are unnecessarily dogmatic. In

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support of this contention, they point out that the suffix -thetic means something "set forth dogmatically" [*Webster's New World Dictionary*, college ed., 1960, p. 1962]. Both evolutionary and path dependent theorists have used managerial economics, network economics, learning theory, and other disciplines as source material for a new, modified production economics with broader implications than homotheticity alone.

The new approach modifies existing theory in six ways. First, there are multiple goals of the modifications. These include providing "a microeconomic basis for explaining technological evolution", [Auerswald, *et. al*, 1998, p. 1] generating behavioral rules for the firm based on "bounded rationality", [Ballot and Taymaz, 1999] and predicting a process innovation path. Such modifications to the production function would allow the firm to invent new products and new inputs, innovate new production processes, mutate existing ones, and cross over from one production plan to another during ever shorter decision periods.

Second, the assumption of perfect certainty is relaxed in favor of a learning by doing [Arrow, 1962; Young, 1993] and a production recipes approach [Nelson and Phelps, 1966; Nelson and Winter, 1982]. Thus, memory, interaction, trail-and-error, and engineering experience are part of the process. The modified production function represents an evolutionary and dynamic process rather than a pre-determined, static outcome.

A third modification is that inputs can consist of non-conventional factors of production such as bio-genetic material, human capital and technological knowledge [Caballe and Santos, 1993] or even nascent (undiscovered) [Auerswald, et. al, 1998]. technologies. Technical and economic behavior of such non-conventional factors is modeled through mesoeconomic application of macro models to the micro firm and the use of engineering experience [Chenery, 1949; Smith 1961] or learning curves to model nascent technologies.

A fourth way that modifications to the economics of production differ from convention lies in the nature of the firm. The firm changes from a sole decision-maker producing a single undifferentiated commodity or manufactured good into an innovating governance structure that invents and produces multiple physical and "weightless" products and services. Giarini and Stahel link this concept to agribusiness in 1989:

> But today, hardware tools and agricultural produce already account for a *minor* part (even if still a relatively large one) of the work actually done in producing wealth and welfare. *Within* the most traditional industries themselves, as *within* agriculture, service type functions predominate. . . . there is evidence of increasing returns of technology precisely in those activity areas which are typically post-industrial or are designated as service functions.
>
> The foregoing is demonstrated in a dramatic way: agricultural overproduction in the U.S. and Europe contrasts with famine in Africa and Asia, because the major economic cost is not in producing these goods, but in storing, transporting, and delivering them. These services account for 80% of the final cost, hence agriculture has become primarily a service activity. [Giarini and Stahel, 1989, p. 1]

Firms use technologies, goods, services, and communication to produce composite services and goods, as well as to produce information and knowledge with which to become more efficient and innovative in the near and distant future. The form of the modified firm ranges from sole proprietorship, to corporation, to what Baarda (1999) calls a "transgenic firm": a loose amalgam of cooperating, semi-independent firms in a supply chain connected through a network of contracts. Hence, the objectives of the modified firm are welded to contractual obligations such as delivery date, quality, and the preservation of downward or upward property rights in the supply chain. These objectives may both internal and external to the firm. The degree of market power can vary by the output from perfect competition to monopolistic competition.

Fifth, whether the firm minimizes costs, maximizes profits or optimizes something else, observed market prices may not be the relative prices used to determine efficiency. This duality in pricing is because "the firm is a set of different subcoalitions each with their own objectives" in the evolutionary school [De Vries, 1999, p. ii]. For example, inter-firm or intra-firm externalities (based on risk taking, asymmetric information, or other factors) can allow a market-priced output expansion path to coexist with an output expansion path based on internalized costs and benefits. Under this view, Bill Gates knew that the source code for DOS was worth more than the few thousand dollars he paid for it as an input to produce MS-DOS. Hence, the firm can face several sets of input prices. First, it faces market prices that are assumed in theory to be fixed as production continues during the production period. Secondly, it faces shadow prices due both to externalities and internal externalities (or "intranalities") [Auerswald, *et. al.*, 1998, p. 9] that may vary as the firm seeks the optimal production technology within a production period.

Sixth, and finally, along with traditional commodities and manufactured goods, outputs in the information economy can include services, information processing, corporate intelligence, bio-tech breakthroughs, or the transfer of data through networks. Many outputs (such as research and development or corporate intelligence) are not sold in the marketplace. Such outputs are hard to measure, but are important as both a stock and a flow. The firm uses the flow of such non-traditional outputs through the organization as catalysts for innovation during the decision period, and may see the stock of these outputs embodied in its market capitalization on each trading day.

In addition to the six modifications in production economics, new technologies modify the economics of production in a second way, seen through new definitions of "increasing returns to scale" from network economics. Economides defines increasing returns to scale as:

> Increasing returns to scale exist when the cost per unit decreases as more units of the good are produced. Recently, the term 'increasing returns to scale' has been used to describe more generally a situation where the net value of the last produced unit [= (dollar value consumers are willing to pay for the last unit) - (average per unit cost of production)] increases with the number of units produced." [Economides, 1998, p.1]

At first glance, this definition corresponds to the economic concept of returns to size rather than the technically based returns to scale.

However, new definitions of returns to scale are based on an alternative view of production and technology where, unlike the conventional definition, market power, penetration rate, and demand responses depend on the technology. For example, Arthur (1989) named several properties of increasing returns to scale technologies. Two of these are non-flexibility (short-run policy levers can create long-run lock-in due to switching costs and customer groove-in) and non-predictability ("small", random events are not averaged out or "forgotten" by dynamics and could decide the outcome). A third property, ergodicity (the opposite of path dependency) occurs when different sequences of events lead to a market outcome with probability of one[15]. Due to these properties, increasing returns to scale technologies are not necessarily path efficient because network externalities accrue rapidly and at an increasing rate to the technology with the largest installed base and not necessarily to the most efficient technology. That is, they may or may not achieve private or social optima.

Ironically, by focusing on decreasing costs and increasing value, this generalized definition of increasing returns to scale (from one part of network economics) obscures the technological cause. The focus on costs conceals the technological causes of increasing returns to scale, given by others that "more and more, biological metaphors are useful economic metaphors" since "change in technical systems is becoming more biological" [Kelly, 1998, p. 114]. To these scholars, increasing returns to scale stems from the biology of human systems, to the dismay of Malthus. Much of "new" economics comes from the chaos-complexity theory of the Santa Fe Institute where fractals, complexity, and emergent computation are metaphors for how simple systems generate complex order spontaneously [Norton, 1999, p. 15]. At Santa Fe, increasing returns to scale could be rooted in anything from nonlinear nuclear physics to molecular biology and enzyme reactions.

Still others argue that the information age and "rising network society" are grounded in "network enterprises" and "the space of flows" [Castels, 1996]. This argument recognizes the detailed technical literature resulting from operations research and communications network engineering (see Chapter 3) as a technological source of increasing returns to scale. Instead of the deterministic models of economics, network engineers venture into probabilistic, variational, and combinatorial models of production where returns to scale, scope, and system occur. With such technical diversity, it is ironic that a widely used definition of increasing returns to scale appears to be based on value and cost rather than on revolutionary technical change.

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[15] Chapter 3 covers the path dependent agenda's "new" economics of networks.

The third example of how new technology is driving modifications in the economics of production can be shown graphically. Figure 2-13 displays a non-homothetic technology with decreasing returns to scale, a pseudo-isocost line, and a curved pseudo-expansion path. The term pseudo is applied to emphasize that the traditional cost minimization model (using observed market prices and single output production) is not exactly what is being used in the case at hand.

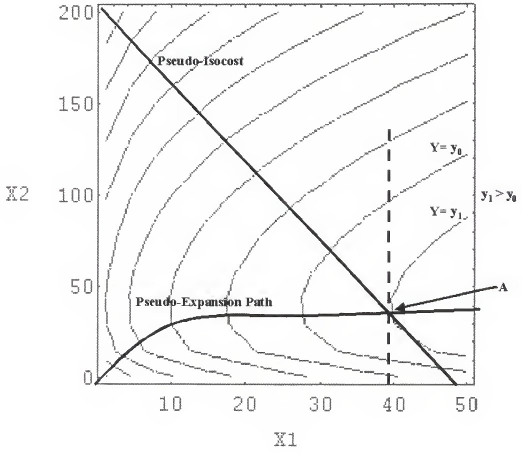

Figure 2-13: An homothetic technology in least-cost proportions.

Suppose that in Figure 2-13, x_1 represents information processing inputs and x_2 represents communication inputs, with the single *depicted* output being the quantity of corporate intelligence (stock or flow). For non-homothetic technologies, technical and economic returns diverge, though not over all ranges of output or all input price ratios. The associated economic cost relation (a function of multiple output levels and a mix of market and shadow input prices) could show increasing returns to size (unit costs fall as output rises). The figure appears to show a traditional economic cost function as an explicit relationship between one output level and two input prices. However, it comes from a system of implicit functions of many outputs and a sizable vector of input prices, some of which cannot be held constant because of jointness in production and factor non-allocability.

Just as in the conventional case, Figure 2-13 is a simplification of reality. In the figure, the firm is attempting to hire the least cost input combination of information and communication. The units and pricing of these inputs are hard to define, but suppose they have been. According to results from both network economics and the evolutionary school, the isoquant pattern shown could result from biological or network hysteresis or a performance plateau effect for a particular set of interactive input technologies. Biological, genetic, and behavioral relationships between x_1 and x_2 could create memory or learning effects, or originate decay, temperature, chemical interactions, or other technological properties. Constraints include such limitations as attention and other implications from the economics of information (see section 2.4) that are not explicitly priced in the market.

However, such a technology (whether hypothetical or real) contains too many mysteries for both the economist and the logician to list. First, note the vertical dotted line running through point A, the cost minimizing bundle given the production budget and price ratios. If more units of x_2 are hired, output falls instead of rising, implying that more is not better. However, in the neighborhood of A, if fewer units of x_2 are hired, output also falls, implying that less is also not any better.

Second, there is the question of replication. For this type of technology to be logically possible, a firm could not hire 40 more units of x_2 and x_1 each to produce A in another location to yield a total of 2A from 80 units of each input. Some inputs would have to be non-rival. Non-homothetic functional forms have many other empirical connotations that worry economists. However, it is important to understand that the problem is framed differently than in the conventional case. Inputs are non-conventional and non-allocable, there are multiple outputs, and the behavioral objectives of the firm (or sub-firm decision making unit) are more complicated in pseudo cost minimization than they are under profit maximization or cost minimization.

The cost of information processing is highly dependent on information technologies, while the cost of communication depends less on the market price of bandwidth than it does on the interaction between the processing technology and human and organizational variables. The internal costs of communication to the firm depend on human variables such as attention and on organizational ones such as specialization, span of control and organizational depth. Costs and benefits can vary through the coordinated interaction of information processing and communication, but are based on an efficient network size, where returns to specialization outweigh all costs of communication.

The evolutionary school would emphasize that the production environment is an uncertain one, especially if the firm is viewed as an interdependent system that learns from its mistakes. Winter argues that the evolutionary model of the economics of production differs in four ways from the conventional or orthodox model. First, the evolutionary firm is a cooperative relationship "among the diverse economic interests organized in the firm" with bounded economic rationality rather than "a unitary actor" that is unboundedly rational [Winter, 1988, pp. 484-487, 493]. Second, evolutionary theory is more capable of explaining and predicting intra-firm organization and behavior than the conventional model which "provides no basis for explaining the organization of economic activity" [Winter, 1988, p. 488]. Third, "textbook orthodoxy fails to provide a basis for understanding the incentives and processes in business firms that produce technological and organizational change" [Winter, 1988, p. 491]. Fourth, boundaries of the firm and the hierarchical economics of managing [Radner, 1992] are always changing in the evolutionary view so that flexible growth based on successful routines is of central importance. As Winter sees it, in the evolutionary school, "the focus of explanatory efforts is on dynamics" [Winter, 1988, p. 492].

The example from Figure 2-13 of non-traditional, non-allocable inputs producing a single input (jointly produced with other outputs) illustrates the arguments of the evolutionary and path dependent schools that many technologies can be non-homothetic. These schools contend that such a relationship could easily arise in the n input case. Such non-homotheticity may be true only within a particular range of input or output levels, such as when an invention is first developed or an innovation first put in practice. Having a broader view of technology is an example of how new technology has modified the economics of production. However, as is discussed later in the context of measuring technical change, the new approaches are often impossible to implement empirically.

Alchian and Demsetz argue that a "metering problem", metering (measuring) input productivity and metering (controlling) rewards is "not confronted directly" in the conventional analysis of production. Instead, conventional analysis:

> "Tends to assume that . . . productivity automatically created its reward. We conjecture that the direction of causality is the reverse --- the specific system of rewarding which is relied upon stimulates a particular productivity response." [Alchian and Demsetz, 1972, p. 777]

The modifications to the economics of production discussed in this section do not seem to provide answers to the metering problem. Instead, because the modifications are due to technological change and rely on the complicated interaction of observable market prices and un-observable externalities and intranalities, there are new unanswered questions to the metering problem than existed in the conventional approach.

According to network economists, superior approaches concentrate on the firm as a communications network [Bolton and Dewatripont, 1994] or rely on the theory of teams [Marschak and Radner, 1972, McGuire and Radner, 1986]. The firm seeks to "minimize costs of processing and communicating information" by reducing the cost of communication measured by "the time it takes for an agent to absorb new information sent by others" [Bolton and Dewatripont, 1994, p. 809]. These views of production as a communications network focus on the next topic, the managerial role played by technology.

2.3.4 Technology's Managerial Role: Efficiency, Flexibility, and Measurement

Both the conventional and modified economics of production and technical change are different perspectives of the technical-economic distinction. However, they are not necessarily applicable to the same economic problems. Technology's fourth role in the information economy is its use as a managerial tool. Viewed in this way, the technology and economics of production are tied to the manager's broad set of economic problems through the firm's "dominant managerial logic" [Afuah, 1998, pp.97-99].

Three forms of efficiency (2.3.4.1) are linked through the flexibility of the firm to sometimes forgotten dimensions of managerial economics (2.3.4.2) such as real and pecuniary economies, internal and external economies, and economies of system and scope. These "economies", in turn, are related to the more technical concepts of returns to system, scale, size, and scope. Proceeding in this manner shows that there is truth to Shapiro and Varian's claim that although technology changes, "Economic laws do not. If you are struggling to comprehend what the Internet means . . . you can learn a great deal from the advent of the telephone system a hundred years ago" [Shapiro and Varian, 1998, pp. 1-2]. Their point is not meant to exclude new technology by defending a narrow view of economics, but to define problems of innovation management clearly and to search economic for appropriate applications. Therefore, the measurement of technological change (2.3.4.3) depends on problem definition and the ability to apply a broad set of economic approaches (that have always been part of economics), in addition to introductory undergraduate microeconomics.

Innovation management uses managerial economics to map technological change onto the modern firm. The field of managerial economics is a loosely-defined collection of economic, finance, marketing, and management theory that is used to understand how firms operate and advise managers about how to operationalize economics in the business world. Results from microeconomics, industrial organization (IO), and production and distribution economics are used to analyze technical change along "incremental-radical" and "economic-organizational" axes [Afuah, 1998, p. 29]. Work in this area does not seek to prove or disprove the "economic laws" of Shapiro and Varian's academic world. Instead, innovation management combines management science and managerial economics to relate the managerial theme of technical innovation to the economic theme of profitability [Afuah, 1998].

The failure to distinguish among the managerial dimensions such as size, scope, system, span, and scale leads to confusion. Paris notes that "economies of scale" (whether real or pecuniary) is a "notion that is rather difficult to define and even more problematic to measure" [Paris, 1997, p. 303]. Even Baumol and Blinder (1991, p. 501) mention that "economies of scale" are "also referred to as increasing returns to scale...", but they and other authors are actually describing economies of size by the more precise Beattie and Taylor definition. The net result of inaccurate problem definition and failure to consult a wide body of economics is that some economists study only a narrow set of technologies, drawing the ire of evolutionary and path dependent scholars. Imprecise meanings bleed into related concepts of internal and external "economies" that help illustrate how the evolutionary view builds upon existing managerial economics.

2.3.4.1 Technology and market efficiencies

The manager's problem depends on efficiency, in spite of Kelly's twelfth rule for the new economy, the law of inefficiencies [Kelly, 1997, p.14]. Technology affects both the measurement and definition of efficiency. Ward (1987) outlines three kinds of efficiencies:

> *Internal efficiency* is attained when firms manufacture and distribute their products using the minimum resources necessary. . . .
>
> *Allocative efficiency* relates to the allocation of resources across markets. It occurs when the marginal conditions are met for all products across all markets. . . .
>
> Finally, . . . *dynamic efficiency* . . . deals with the optimal allocation of resources over time. This aspect is particularly difficult to evaluate since by its very nature the optimal level is changing as technologies change. [Ward, 1987, p. 210]

When it comes to technological change, it is clearly possible for a firm that insists on making electric typewriters rather than word processing equipment to be internally efficient, but dynamically inefficient. This is the first challenge technological change makes to conventional economics: an efficiency measure for the firm that keeps up with (even anticipates) technological change in the environment. However, it is hardly a new, unanswered challenge.

Drucker's point that defining efficiency as doing the job well, rather than doing the right job can cause any of the three efficiencies to be inaccurate measures of "true" efficiency, regardless of how precisely they are measured empirically. This is a second challenge technological change makes to conventional economics: the accuracy of economic definitions of efficiency.

The third challenge technological change makes to the conventional view of efficiency relates to organizational form. A particular department in a corporation may have internal efficiency, but that does not guarantee that this will be transmitted throughout the entire organization. Even if the first two challenges are answered, efficiency of organization is essential to technical change. For example, a large firm may be unable to adjust internally to external technological change or make the technological changes internally it needs to alter external efficiency to reach its objectives.

Internal efficiency was already mentioned under the discussion of supply side or production aspect of technology. The idea was discussed by Sraffa (1926) who amplified Marshall's view that internal and external "returns" differed since internal and external efficiencies were different. However, internal efficiency depends on the decision period, time horizon, and discount rate. Internal efficiency is often seen as a SR or VSR measure that is easily measured by the firm. However, it can be difficult for the firm to assess how technological change affects internal efficiency.

Allocative efficiency is also related to technology in several ways. First, when allocative efficiency is measured, a distinction is made between cost-based, revenue-based, and profit-based allocative efficiency, depending on whether cost minimization, output maximization, or profit maximization is the yardstick [Chavas and Cox, 1999]. Allocative efficiency is an external efficiency to the firm. Therefore, unless the firm has market power, it will have to make medium term adjustments as the market maintains allocative efficiency.

Dynamic efficiency is known also as adaptive efficiency. The decreasing costs over time of hypercommunication technologies are sometimes considered examples of dynamic efficiency. For example, the new, lower price of a three-minute New York to London telephone call became only $21.00 in 1936 [Oslin, 1992, p. 281]. A much higher quality direct-dialed call costs less than $0.50 today. (In real terms, the difference is even more dramatic since $21.00 in 1934 had the buying power of $260.37 today, meaning the call was 536 times more expensive in 1939 than in 1998). Innovation management and managerial economics can be used to consider how internal, external, and dynamic efficiency translate into innovative efficiency, or the ability to retain a particular kind of efficiency given technical change.

A final point concerns the argument that technological control can be a managerial weapon that can actually ruin efficiency in certain cases. Specifically, some argue that a "dictatorship of high-tech management" based upon "endemic, structural" managerial distrust of workers means that lower-tier high technology workers end up with a return to the "despotic factory regime" [Devinatz, 1999]. In this view of the labor market, rather than melting away labor market failures economic theory suggests, the asymmetric information and better technology available to firms are used as weapons to tightly monitor and control workers. Worker privacy can be invaded while every aspect of performance is quantified from average length of bathroom breaks to mean time spent handling customer inquiries. If efficiency is not tinged with qualitative considerations, the firm can be left with a harried, terrified workforce that seeks to minimize the time spent helping customers or performing tasks.

2.3.4.2 Flexibility and managerial dimensions

One way to link the three efficiencies to managerial dimensions such as size, scope, and system is by thinking about the flexibility of the firm. Operational, tactical, and strategic flexibility play roles in each dimension much the same way that the traditional VSR, SR, LR, and VLR do in conventional analysis. The evolutionary school's view of the flexibility of the firm helps clarify the idea of additional dimensions beyond scale and size to include system, span, and scope. Rather than complicating things, ideas about flexibility link existing economic concepts to a modified, systematic view of the economics of production.

Carlsson (1989) argues that the "flexibility" of a firm has more dimensions than suggested by the conventional notion of how the firm adapts to output demand fluctuations based on the shape of the cost curve (Stigler, 1939). Instead, there are three kinds of flexibility: short-term (operational) flexibility, medium-term (tactical) flexibility, and long-term (strategic) flexibility.

Operational flexibility is "built into the 'software' of the firm in the form of procedures, which permit a high degree of variation on a daily basis in sequencing, scheduling, etc." [Carlsson, 1989, p. 201]. On the technical side, operational flexibility is assisted by IT, better communications, and by networked technology. On the economic side, the improved knowledge helps the firm take advantage of discounts, real-time pricing, and auctioning to become more efficient economically in production and inventory. Required materials can be bought cheaply in bulk, while carrying costs are minimized through better timing. Internal efficiency is the main efficiency focus of tactical efficiency.

Tactical flexibility is:

> ...built into the technology, i.e., the organizational and production equipment, of the firm which enables it to deal with changes in the rate of production, or in product mix over the course of the business cycle, as well as moderate changes in the design of its products. [Carlsson, 1989, p. 201]

Tactical flexibility is assisted on the technical side by networking infrastructure and high tech equipment, along with a corporate intelligence stock that optimizes control and information over transportation, marketing and finance. On the economic side, the firm benefits from economies of system and scope. Economies of management, marketing, and finance result from size and efficiency.

One aspect of tactical flexibility is increased customization due to computerization.

> Consumers . . . should be able to look to a future where they will not need to compromise as much as hitherto with the manufacturer's conception of the 'median taste' . . . although the biggest gain will go to those with snobbish or otherwise idiosyncratic tastes. [Leijonhufvud, 1989, p. 171]

The ability of firms to tailor their hypercommunication technologies to specialized customer needs and the increased use of personalization in business-to-business (B2B) e-commerce are additional examples.

However, the new ability to customize does not banish scale economies to the old economy. The fact that

> smaller batches will become economical does *not* mean that the economies of large scale are weakened. It means, rather, that the economies of assembly line production can be obtained while turning out differentiated products. [Leijonhufvud, 1989, p. 171]

The third flexibility, strategic flexibility, takes advantage of built-in operational flexibility and the firm's greater ability to customize output and communications. However, strategic flexibility is even more far-reaching because it:

> ...encompasses the ability to introduce the new products quickly and cheaply, to accommodate basic design changes, and, most importantly, the nature of the organization of the firm and the people in it, their attitudes and expectations, particularly with respect to risk-taking and change. [Carlsson, 1989, p. 201]

Strategic flexibility depends on communication technology, the information literacy of employees, and the corporate culture. It depends on the technical ability of the firm to copy and distribute non-rival inputs. On the economic side, dynamic efficiency, the ability to recognize new opportunities and threats and operationalize response is enhanced by the flow of corporate intelligence and resulting lower unit costs of research and development.

The three flexibilities are closely related to familiar terms from managerial and resource economics. The first dimension is the distinction between real (or technical) economies of scale and pecuniary economies of scale. Here, the idea is that technical economies of scale come about due to "savings in labor, materials, or equipment requirements per unit of output resulting from improved organization or methods of production made possible by a larger scale of operations" [Viner, 1931, p. 213]. Quantity discounts made possible from a larger size (rather than from increased production using existing size and technology) are one example of pecuniary internal economy. Again, the difference between the purely technical and the economic view appears important. Pecuniary internal economies are most correlated with operational flexibility, while real economies flow to all levels.

A second dimension concerns the size of the firm relative to the industry, or whether any economies of scale or size are internal or external. In this sub-section, the discussion concerns internal economies, but external economies are considered in the context of technology and supply in 2.3.5. Note that internal economies include economies in management, marketing, and finance, but that these may be external also. From the first dimension, the size-scale distinction can be viewed according to the difference between real and pecuniary economies of scale. From the second dimension, the size-scale distinction can be viewed as internal or external.

2.3.4.3 Problems in measuring technological change

Technological change can conceivably be measured as a rate, direction, velocity, discrete jump, or component of the rate of economic growth. The induced innovation and endogenous growth agendas are most readily represented by conventional economic models, while the evolutionary and path dependent approaches are establishing their own theoretical and empirical methods for measuring technical change. To some, the debate among the four agendas hardly bears on the economist's role of providing empirical measuring rods. For example, while Chambers remarked "there appears to be no exact consensus on just what causes technical change", he did find that "technological change and its consequences for observable market behavior" could be (albeit imperfectly) described by conventional economics [Chambers, 1984, Ch.5, p.1]. This could be done either by defining technical change as a continuous phenomenon and using differential calculus or by defining it discretely using index numbers of production or cost. In either case, the ability to model technical change depends on mathematical assumptions and restrictions on technology as represented by conventional production or cost functions.

To others, conventional economics' limited ability to measure new technological phenomena has necessitated new research agendas. According to Arthur (1990), economics has "suffered from a fatally simple structure imposed on it in the 18th century" as it struggles to become a field where path dependencies and synergies are recognized. By discarding outmoded (and possibly violently incorrect) measurement methodologies Arthur argues, " . . . economists' theories are beginning to portray the economy not as simple, but as complex, not as deterministic, predictable and mechanistic but as process-dependent, organic, and always evolving" [Arthur, 1990, p. 97-98]. The best set of measuring rods may be from biology, nonlinear physics, and nonlinear probability theories in non-static (even chaotic) environments where multiple or punctuated equilibria "phase lock" the outcome away from Newtonian order.

The difficulty encountered in decomposing a technological change graphically as illustrated in Figure 2-12 is multiplied when a more general approach to measurement is taken. Measuring technological change depends on several factors. First, measurement depends on how technical change enters the production, cost, and profit functions. Second, it depends on whether the rate of technical change, total factor productivity, partial factor productivity, or another measure is taken. Third, the empirical measurement of technological change depends on the periodicity used, especially when technological change is a residual or trend term in a regression equation.

Technology can be modeled as a longitudinal change in a single firm's production function or as how production functions differ among firms. This is even consistent with evolutionary work such as Dosi's (1984) approach of identifying examples of technological change in separable technical and economic features of product and production process. It also can be measured as an explicit direct input, as an indirect input, or as a residual measure that equates the passage of time with technological change.

Many economists find there is a more efficient approach to modeling technology's effect on a firm or economy than constructing a production function for every possible case. While it may be part of the engineer's paradigm to map the details of production functions explicitly, the economist finds a more efficient approach to be to set up some general properties of technologies. Jehle (1991) explains the rationale:

> If we begin with a technology and derive its cost function, we can take that cost function and use it to generate a technology. If the true technology is convex, the true and implied technologies are identical. If the true technology is not convex, the implied technology is a 'convexification' of the true one. Moreover, any function with all the properties of a cost function implies some technology for which it is the cost function.
>
> This last fact marks one of the most significant developments in modern theory and has important applications for applied work. Applied researchers need no longer begin their study of the firm with detailed knowledge of the technology and with access to relatively obscure data. Instead, they can concentrate on devising and estimating flexible functions of observable market prices and output and be assured that they are carrying along all economically relevant aspects of the underlying technology from the estimated cost function. [Jehle, 1991, pp. 237-238]

Some of the difficulties with the dual approach have already been explored. Two aspects in particular are considered. First, modifications of the dual approach to multiple outputs, non-homothetic production functions, and DEA (Data Envelopment Analysis) or the frontier production function offer hope for a modified dual approach to remain the cornerstone of measurement.

The approaches of alternative schools to non-continuity, alternative objectives, multiple technical changes, and organizational aspects of measuring technical change can be outlined. In cases where duality theory is unable to reconstruct certain technologies, economic factor interdependence and the direct and indirect importance of relative prices are considered. Alternative schools show potential in creating empirical methodologies capable of testing their theories and quantifying technical change in new ways.

The separability of technology and the treatment of technology as a residual in the production function are examples from a large set of conventional restrictions that alternative schools question. Chambers notes that separability "requires that the elasticity of the marginal product of x_i with respect to x_k equal the elasticity of marginal product of x_j with respect to x_k" [Chambers, 1984, p. 1-28]. This imposed symmetry seems hard to balance with non-neutral technological change if technology itself was a variable in the production function. In terms of the cost function, separability implies Allen elasticity of substitution term σ_{ik} will equal σ_{jk}, or "complete equivalence of the substitution effects" [Chambers, 1984, p. 2-62]. The issue is a complex one when continued to the profit function case because separability of the cost function and separability of the profit function have different implications for the underlying technology. As Chambers states, "separability of the profit function does not necessarily imply separability of the cost function" [Chambers, 1984, p. 3-34]. Separability of the cost function involves movement along isoquants, while separability in the profit function places restrictions on derived demands along isoquants and as output changes [Chambers, 1988].

There are many ways of modeling the economic aspects of production, using inputs as independent variables or using output as the independent variable. The firm can seek to maximize profits or output or to minimize costs, subject to constraints. So far, the discussion has centered only on how technology changes the production function alone. However, technology itself can change the nature of the firm's profit function, cost functions, derived demands for inputs, conditional factor demands, and the opportunity costs of binding constraints (shadow prices).

Mathematical development of all the "economically relevant aspects of underlying technology" that can be captured using duality may be found elsewhere. The main point is that the dual approach can be used to observe the behavior of technology in cost and profit functions, not just in production relationships. As Jehle mentions:

> Just as with cost-functions, there is a full set of duality relations between well-behaved profit functions and well-behaved technologies. In both its generalized and restricted forms, every function with the required properties is the profit function for some technology with the usual properties. The generalized profit function is therefore sufficient to characterize competitive firm behavior when all factors are variable, and the short-run profit function is sufficient to characterize behavior when some factors are fixed. [Jehle, 1991, p.249]

However, increasing returns to scale are not consistent with profit maximization in conventional thinking. Hence, the generalized profit function is not sufficient.

The argument that duality reduces the economic role of technology in production to an artificially simplistic level due to restrictions is being mitigated by advances in analysis that push the boundaries of the approach into the information economy [Chambers, 1997]. Just as Morgenstern (1963) predicted, the very technologies and organizational arrangements that previously restricted the approach are allowing it to become more productive.

2.3.5 Technology and Supply

The next major role played by technology in the information economy is in industry supply. On an aggregate level, improved technology can shift an entire industry's supply curve (or an entire economy's supply) outward, but the change does not happen in an economic vacuum. Three topics of importance to agriculture are considered. The first topic concerns decreasing cost technologies and industry supply behavior. Another topic is the so-called treadmill theory of technology. The third topic concerns the supply-push explanation for the source of technology.

If all firms in an industry use a homothetic technology with increasing returns to scale and operate at maximum technical efficiency, then a proportional increase in all inputs will lead to a greater proportional rise in output [Chambers, 1997]. If all firms in an industry enjoy increasing returns to size, then increases of all inputs in least cost proportion lead to a greater proportional rise in output and decrease in costs. For larger, more complex firms, if all firms in an industry enjoy increasing returns to scope or organizational form, management, etc., increases of all inputs in optimum combination will lead to greater proportional increases in multiple products (in optimum combination). Dynamically, increasing returns and decreasing per unit costs decrease output price. Firms then attempt to decrease costs further by becoming larger, but this decreases output price again. Hence, the idea of a treadmill comes from the continual attempt by firms to adopt new technology to make up in volume what is lost on a per unit basis from industry-wide adoption of new technology.

The attempt to name the kinds of industries where increasing returns prevailed led to a classical debate between Lord Clapham and Pigou in the 1920's, along with influential papers by Robinson and Viner [Clapham, 1922a, 1922b; Pigou, 1922; Robertson, 1924; Sraffa, 1926; Robinson, 1926; Viner, 1931]. Ever since that time attempts to definitively identify decreasing cost industries have been stymied in economics. Network, evolutionary, and path dependent approaches appear bent on using new methods to identify the underlying technologies that create external economies of size. For example, from the evolutionary perspective, "It is essential to... allow price signals a more dynamic role than that of 'sustaining equilibrium responses." [Nelson, Winter, and Schuette, 1976, p. 91]

A second topic in technology and supply is the technology treadmill argument. In the perfectly competitive world of production agriculture, technology is often likened to a treadmill. Early adopters jump on first often achieving super-economic profit. If the technology is skewed towards a larger scale or size of operation, this (along with the fact that competitors must adopt or exit) exacerbates the technological change. Supply shifts out, price downward, and only with increases in size can firms survive.

A third topic concerns the supply-push, science-push, and technology-push views of innovation that "science and technology" are a "relatively autonomous process leading to industrial innovation" [Mwamadzingo, 1995, p. 1]. Invention, innovation, and macroeconomic growth because of technology spillovers are important roles technology plays in supply affecting agriculture.

Research and development investments by firms and government produce technology as an output [Jaffe, 1986]. Technological spillovers happen because:

> (1) . . . firms can acquire information created by others without paying for that information in a market transaction, and (2) the creators (or current owners) of the information have no effective recourse, under prevailing laws, if other firms utilize information so acquired. [Grossman and Helpman, 1991, p.16]

Such technological spillovers are particularly important to the process of economic growth:

> The general information that researchers generate and cannot prevent from entering the public domain often facilitates further innovation.
>
> . . . Thus innovation conceivably can be a self-perpetuating process. Resources and knowledge may be combined to produce new knowledge, some of which spills over to the research community, and thereby facilitates the creation of still more knowledge. [Grossman and Helpman, 1991, p.17]

Hypercommunications especially facilitate the spillover process because "rapid communication and close contacts among innovators in different countries facilitate the process of invention and the spread of new ideas. " (Grossman and Helpman, 1991, p. xi)

Roger Noll summarizes: "research ... in the last few years ... which has put some serious meat on an explanation" of "basic or undirected non-commercially oriented research that takes place in universities, national laboratories" that "leads to expansion of the economic base of the nation and the national welfare, not only in the U.S., but worldwide" [Noll, 1996, p.37]. He adds:

> The research in the last five years has found it remarkable that the productivity of privately applied product development research is higher in areas which are near a university than in areas where it's not. [Noll, 1996, p. 38]

In agribusiness, the role of the Extension system in technology transfer is an obvious one and may depend on how "near" firms are to the university through communications and desire for new technology. Production agriculture's marketing and production functions should be enhanced the most by hypercommunication technologies in rapidly consolidating sub-industries such as Florida's growing billion-dollar nursery-greenhouse industry. Rural communities' future industrial, educational, and employment skill bases are each dependent on rapidity of technology transfer to information economy.

A final note comes from Douglass North who points out that "productivity increases result from both improvements in human organization and from technological developments" [North, 1994, p.1]. Until now, few attempts have been made to distinguish between institutional innovations and purely technological ones. Importantly, technological innovations from IT and hypercommunications have enabled a variety of new institutional arrangements. While these affect supply by "lowering either transaction and/or transformation costs" at the firm level, they come from outside the firm [North, 1994, p.2].

Of North's four institutional innovations that have classically lowered transactions costs through history, all four (increased mobility of capital, lower information costs, creation of risk spreading institutions, and improved enforcement of contracts) have escalated due to IT and better communications. Indeed, wire funds transfer, real-time market data, real-time trading and auctioning, and lower costs of communication are hallmarks of the information economy. Communications and information technologies, while external to the firm, can provide internal economies (Sraffa, 1926) for well-organized firms especially when the technologies allow firms and industries to participate in new institutional arrangements.

2.3.6 Technology and Demand

The role technology plays in consumer and producer demand is the fifth major role of technology in the information economy. Specific technologies affect the demand-side or consumption in several ways. In hypercommunications, for instance, advances in software and hardware allow advances in hypercommunication services, while de-regulation offers consumers more choices. For agribusinesses, new production and distribution technologies can preserve freshness, improve quality, and promote better food safety, leading to greater consumer confidence in products on the demand side. In this sense, demand may become more inelastic or a new, differentiated product may give the firm an advantage. However, if consumers misunderstand or fear the technology, their negative perceptions may hinder the profitability of technology as in the case of food irradiation or genetically engineering foods.

In this section, three topics are briefly explored. First, the ability of technology to shift the demand for an existing good is a promising way hypercommunication technologies can influence agribusiness markets. Second, the introduction of a new product or service is subject to a diffusion of innovation process both for the introduction of a completely new good to consumers and for the penetration of technological inputs in agribusiness. Third, the competitive effects of technology can stimulate or discourage competition.

The economics literature contains many examples of the role of technology in demand. The first two topics result from two of Schumpeter's five categories of technological innovation. Schumpeter's other three categories relate to demand indirectly through supply. The first category of technological innovation is a new good or new quality of good. By increasing consumer choices, technology produces new substitutes and complements for existing goods in addition to creating entirely new products. The second Schumpeterian category of technological innovation is a new method of production. This form of innovation has already been considered in 2.3.2, but new production methods can alter derived demands for inputs by firms. The third category, the opening of a new market for an existing good, is clearly relevant to agribusiness and hypercommunications, as globalization of markets opens new opportunities. Demand in these new markets can stem from new uses for a good due to technology, or through a widening of market boundaries through better communications or improved logistics. The fourth technological innovation is the discovery of new resources or intermediates. Again, this category relates more to a production and supply framework. The fifth and final technological innovation category named by Schumpeter is a new organizational form. Organizational form relates mainly to technology's managerial role and only indirectly to demand through the demand-sensing and demand-serving roles of agricultural marketing firms.

2.3.6.1 Technology and demand for existing products

The first topic is technology's ability to shift demand for an existing consumer good or producer input. The simplest way to see this is to consider the case where technology creates a new product that is almost a total substitute for an existing product. The demand for computers versus the demand for typewriters is one example. Even before the PC word processor displaced the electric typewriter, electric typewriters tended to substitute for manual typewriters. The main issue here concerns how firms can speed up (or slow down) the speed with which the new supplants the old.

Similarly, on the demand side in input markets, new technology may stimulate demand for one (or more) inputs while shifting the demand for others inward. In many ways, technology's role in demand is familiar territory for agribusinesses. This is most true for the producer's derived demand for inputs. Gould and Ferguson noted this in 1980:

> It should be apparent that technological progress changes the marginal productivity of all inputs. Thus a technological change that makes a variable input more productive also makes the demand for any given quantity of it greater, and vice versa." [p. 360]

This point was discussed in detail in 2.3.3.

The issue of technology in demand is a particularly important one in the network economics of the path dependent school. In addition to edging out old substitute technologies, new technology creates perfectly complementary network technologies. Once the Windows operating system is installed on a computer, MAC software packages become instantly useless, while software applications that are compatible with Windows become perfect (if they work!) complements. The size of the installed base becomes an extremely important predictor of demand. "Demand" economies of scale occur for a product if "the more customers that already own it, the more want it" [Afuah, 1998, p. 362].

This can be based on bandwagon or Veblen effects [Liebenstein, 1948] or du e to network externalities [Katz and Shapiro, 1985]. Network economics is discussed in more detail in Chapter

3. However, the idea of a network externality is based on the value of a good rising as more have access to it. One example is that of the telephone. A telephone that connects its user to one other station is less valuable that the same telephone would be if it connects its user to 400 million other telephone subscribers. Yet network externalities on the cost side mean that as costs are spread across more users, the cost of each telephone falls dramatically.

The path dependent view includes Arthur's (1989) statement that increasing returns "might drive the adoption process into developing a technology that has inferior long-run potential" [Arthur, 1989, p. 117]. However, he admits that "sometimes factor inputs are bid upward in price so that diminishing returns accompany adoption" [Arthur, 1989, p.117]. At first glance, such path dependent outcomes from network economics (see also Chapter 3) might appear only to affect IT and knowledge-based industries.

However, many of the technologies in agriculture (typically not defined as knowledge-based) change demand for inputs in similar ways. For example, the practice of monocropping (while condemned in some circles) could be an example where farmers band together to take advantage of management and equipment networking efficiencies they would be unable to use otherwise. For example, if most farms in a certain area plant wheat or cotton (installed base), then co-operatives, equipment sharing, and exchanges of cultural advice among similar operators is a de facto path dependent network. Equipment sharing, discussion of cultural practices, similar chemical and fertilizer requirements, labor arrangements, and other practices could be considered network effects that are locked-in due to an installed base. Hypercommunication and IT simply offer agribusinesses new institutions with a larger possible size to accomplish these networking activities.

While these references are to supply and input demand, specific network technologies also influence consumer market demand for the agribusiness products. For some crops, oranges, avocados, and livestock, longer life cycles (seven years until first production from avocados, for example) are examples of lock-in to an installed base. However, networks of producers (called producer organizations) often use communications technologies (such as advertising and promotion) to influence demand. New methods of food shopping (Internet groceries or direct farm-to-household sales), along with the trend towards nutraceuticals, organic foods, and humane production are a few of the ways technology affects market demand in agribusiness.

2.3.6.2 Technology and demand for new products: diffusion of innovation

The second topic in the technology of demand is the diffusion of innovation. Diffusion of innovation is the process whereby a given technology goes from theory to practical use. Importantly, the diffusion process is indirectly at work in the economics of technology and production, and, hence, supply too. However, it is most straightforward to analyze diffusion of technology in terms of demand for a new technology by using proxies such as sales and penetration rate.

In this process, several actions occur such as technology transfer, invention, innovation, and adoption. Often an S-shaped curve (with sales or penetration fitted to time) suggests that (after research and innovation are complete), the diffusion process consists of six stages, early, middle, and late adoption, followed by early and late maturation and then decline. Empirical research from marketing documents two important aspects of diffusion theory for consumer products that applies here [Bass, 1969; Bass, Krishnan, and Jain, 1994]. First, diffusion is a social and educational phenomenon whereby the current level of diffusion depends on how many people have already adopted the technology. Different socio-educational or socio-economic groups with particular psychographic profiles (innovators, early adopters, early majority, late majority, and laggards) are associated with each stage [Daberkow and McBride, 1998]. Second, firms that seek to influence the rate of diffusion by using marketing decision variables such as advertising or strategic pricing can speed up the diffusion of technology. At first glance, these results would appear to be mainly related to technology and demand. However, the diffusion process is at work in the adoption of a new production technology that affects the speed of supply response to technological change. Finally, market competitiveness and market efficiencies are both affected by rate of technological change and the behavior of prices through time. These can depend on the diffusion of innovation, but they are also related to the competitiveness of the market subject to the technological change.

2.3.6.3 Technology and competitiveness

A third role played by technology in demand is its effect on the competitiveness of markets. Market competitiveness may be on an intra-industry level, or it can be inter-industry competitiveness due to technology's ability to redefine substitute and complementary goods. The latter point is particularly applicable to hypercommunications convergence. For example, BellSouth has gone from natural monopoly to a firm that competes with other LECs (Local Exchange Carriers) for local dialtone and other telephone services. However, convergence and deregulation increase the set of competitors to include cable TV firms, ISPs, electric utilities, and satellite providers.

Technological progress can be pro-competitive, anti-competitive, or neutral. As McNamara wrote in 1991 concerning telecommunications technology:

> Technological change is usually defined as an increase in the menu of existing techniques for producing goods and services or an increase in the number or types of products that may be produced. The selection of new productive techniques or new products or both from the enhanced menu of technological opportunities depends on the relative economic advantages of those decisions. Included in the term economic advantages may be some extremely sophisticated economic and political strategies that may be intended to strengthen the firm's long-term position in its market by deterring competition, rather than just to exploit some immediate cost or market advantage. [McNamara, 1991, p.127]

Under this view, firms such as AT&T or AOL-Time Warner may seek to reduce consumer choice through mergers and acquisitions. AT&T is now able to offer local telephone service, cable TV, high speed Internet, cellular, PCS, and data networking services through its purchases of cable TV giants MediaOne and TCI. By redefining the field of competition (while on its acquisition spree), AT&T scored regulatory approval to re-enter the local telephone business.

Grossman and Helpman (1991) argue, however, that technology's effect on competitiveness is, in reality, a net social positive because of technological spillovers.

Technology may be defined as a non-rival good, so that "when one agent uses technology to produce a good or service, this action does not prevent others from doing so, even simultaneously" [Grossman and Helpman, 1991, p. 15]. Furthermore, they add:

> . . . technology in many cases is a partially non-excludable good. That is, the creators or owners of technical information often have difficulty in preventing others from making unauthorized use of it, at least in some applications. [Grossman and Helpman, 1991, p.16]

The hypercommunications market structure eventually will depart from the extremes of perfect competition (or perhaps monopolistic competition) of ISPs on one hand, and "natural" monopoly of ILECs on the other hand. Before hypercommunications convergence, these were separate markets for separate services in co-existence. Convergence due to technology may result in a mixture of large, complex telecommunications firms and engineering-intellectual entrepreneurial players engaging in a fast-paced game of mergers, acquisitions, and strategic partnerships designed to gain market power. It is even less clear how hypercommunication technologies (or other new technologies) will affect the market structure of agriculture. Large agribusinesses may become larger and perhaps fewer. Yet, innovative agricultural producers may benefit from new market niches, leaving competitors who fail to adopt hypercommunications (or other) technologies behind.

Many other topics regarding technology and demand exist beyond the three just mentioned. One concerns how demand shall be analyzed theoretically or empirically when rapid technological change results in successive quality generations of durable products. For example, a computer in 1950 and a computer in 1995 are dramatically different. This first problem is hardly new to empirical attempts to model demand and forms the rationale for approaches ranging from index number construction to compensated demand theory. A second technology-demand topic is the implication on market efficiency and welfare due to improved information and lower search costs from technology. This second topic leads to the third foundation of the information economy, information to be covered in 2.4. However, first it is important to note that technology and information have so close a linkage (beyond the obvious information technologies) that it can be hard to differentiate the two.

2.3.7 The Technology-Information Linkage

The sixth and final role of technology in the information economy concerns the linkage between information and technology. Technology's relationship (through hypercommunications) to the conceptualizations of information (section 2.4) is important economically to the firm because information can be an input to a profit-generating governance strategy and an output. Hypercommunication technologies enable firms to improve internal technologies based on newly discovered opportunities found because of better information.

Thus, technology's definition *itself* depends on how information is conceptualized and *vice versa*. Hypercommunications requires a particular set of technologies that improve the exchange of information. Hypercommunication technologies tend to be invisible to users of hypercommunication services[16]. Recall that hypercommunication technologies denote the hardware, conduit, software, and protocols within the "applied science" that power communications alone. The usefulness of hypercommunications as an input is two-fold. First, it provides a direct effect by reducing the costs of existing activities due to the use of hypercommunication technologies. Second, there is an indirect effect that stems from new activities, interactions, and non-hypercommunication technologies made possible because of increased information.

Therefore, hypercommunications can result in technology spillovers covering all sectors of the economy, not just within the hypercommunications sector. Hence, hypercommunication technologies are part of a class of technologies that have both direct and indirect effects. This underscores the importance of access to hypercommunications for agribusiness, production agriculture, and rural communities. Improvements in hypercommunication technologies enable innovations, technology spillovers, and growth for agriculture, even though the applied science of agriculture and applied science of hypercommunications differ substantially. Information technologies (IT) represent an important overlap between the two. This overlap improves innovation, implements production efficiencies, allows communication and control over greater distances, promotes access to more information, and better organizes market intelligence. However, such technologies are most productive when interconnected to internal or external networks through a hypercommunications infrastructure.

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[16] This is, at least, the goal. Users of a hypercommunications service often are concerned with the details of the underlying technology when there is a problem of interconnection or compatibility. The seamlessness of a technological change refers to the ease and invisibility with which services are linked among platforms, locations, routes, and carriers.

Monk delineates links between information and technology in much the same way that economists distinguish innovation from invention. A technology is composed of sets of information while technological information is the means by which technology is implemented. Further, "sets of information which have no potential use value in production cannot be considered as part of technology". Monk also distinguishes between the absolute and effective states of technology based on how available information concerning that technology is. The "absolute state of technology" depends "on the content of the technological information sets that exist". However, the effective state of technology "depends on both the existence of technological information sets and on the availability, distribution, and allocation of the embodied forms of that information" [Monk, 1992, pp. 38-39].

2.4 Information, the Third Foundation

Like technology, information is a fundamental concept of the information economy, as well as central to the study of hypercommunications. However information is often defined so broadly (or not at all) that it is often hard to pin down a useful economic meaning ---even in the context of buzzwords such as "information age", "information superhighway", "information society", and "information elites". The truth of this is pointed out by Braman: "The abundance and diversity of definitions of information bewilder." [Braman, 1989, p. 233] Instead of trying to reveal a single "true" linguistic definition, this section offers several operational definitions in the context of hypercommunications and the economics literature. Whatever it means, information's critical economic role has been highlighted through the phrase information economy.

Seven conceptualizations and economic roles of information are discussed that go beyond basic dictionary definitions. The seven are shown in Table 2-3. First, information may be considered as a stock or a flow. A second, closely related way to view information is as a resource or a commodity [Braman, 1989, p.235-236]. A third way labeled by Braman as "perception of pattern" is considered here as a group of processes: information processing, information diffusion, information literacy, and information used to solve problems.

Table 2-3: Conceptualizations and economic roles of information.

Conceptualization	Role	Location
Stock or flow	Method of pricing	2.4.1
Resource or commodity	Input (data), output (information)	2.4.2
Perception of pattern	Information literacy, diffusion, processing, and use in problem solving	2.4.3
Major economic properties of information	Direct and indirect source of value, search costs	2.4.4
Public good	Externality, imperfection	2.4.5
Asymmetry and symmetry	Determinant of competitiveness and efficiency	2.4.6
Other economic properties of information	Uncertainty reducer, organizational aid, information as a "bad"	2.4.7

The last four conceptualizations are developed from important strains of the economics literature. A fourth conceptualization of information includes major economic properties such as the direct value of information or through indirect values such as search costs. Fifth, information may be conceptualized as a public good. Sixth, information can be a market competitiveness variable due to information asymmetries among economic agents. The seventh and final conceptualization is a catchall category to include other economic properties of information.

One dictionary definition of information begins with the transitive verb inform as meaning:

> 1. a) To give form or character to; to be the formative principle of. b) To give, imbue, or inspire with some specific quality or character, animate. 2) [Rare], to form or shape the mind; teach. 3) To give knowledge of something to; tell, acquaint with a fact, etc. [*Webster's New World Dictionary*, college ed., 1960, p.749]

Knowledge, learning, and wisdom are sometimes considered to be synonymous with the noun information which "applies to facts that are gathered in any way . . . and does not necessarily connote validity" because there is also "inaccurate information". Knowledge "applies to any body of facts gathered by study, observation, etc. and to the ideas inferred from these facts and connotes an understanding of what is known". Learning "is knowledge acquired by study; wisdom implies superior judgement and understanding based on broad knowledge" [*Webster's New World Dictionary*, college ed., 1960, p. 750]. However, these linguistic distinctions do not hold uniformly across all seven conceptualizations of information.

2.4.1 Information Conceptualized as a Stock or Flow

Under this conceptualization, information can be measured. Indeed, stock and flow measures are regularly used in billing market exchanges between hypercommunications suppliers and their customers. Stock or flow measurements may also be needed for accounting reasons, to provide a numeric tally, or for broader strategic or philosophical purposes. This conceptualization is applied, rather than theoretical, and is worth attention because information exchange is often priced based on stock and flow measures.

As Chapter 4 will demonstrate specifically, pricing of hypercommunication services is often characterized in four ways: metered, measured, unlimited access, or content subscription. The prices encountered in the market are sometimes a combination of these four but do not include fixed installation fees or recurring equipment charges. One metered service that is most familiar is the long-distance telephone call, priced typically on a per-minute basis for lineside services. Metered services charge customers based on units actually used. Other metered hypercommunication services are priced by bits transmitted.

Measured services typically are sold on a plan basis where up to a certain number of bits or minutes are assessed at one overall rate regardless of the amount actually used. Additional units over the plan level are often priced at a higher metered rate. Many cellular telephone plans are examples of one type of measured service.

Hypercommunications carriers regularly bill for other measured services based upon the number of bits transmitted by a circuit within a particular period rather than length of transmission in time or distance. Additionally, the flow of information down the circuit is compared to a pre-subscribed capacity for measured "bandwidth on demand" services. With frame relay service, customers are guaranteed a Committed Information Rate (CIR) where a minimum bandwidth is guaranteed available when needed for a fixed plan price. However, a higher (metered or measured) rate is paid to transmit information above the CIR up to a certain bandwidth ceiling when available. The bandwidth measure itself is a stock measure of information carrying capacity, rather than a flow measure of information actually transmitted.

Third, there is unlimited access pricing which is the industry standard for narrow-band dial-up Internet access for example. An (ISP) Internet Service Provider's customer is charged the same amount whether connected to the ISP's modem bank for one minute in a month or 100,000 minutes a month.

Finally, information can be priced based on content or accessibility. Subscriptions to magazines and market newsletters are old examples of pricing by content. In the hypercommunication era, they are joined by subscription-only websites and online research services that respond to e-mail research queries. Online sales of music tracks (MP3 files) and live or recorded video feeds are other examples. New software and hardware technologies can prevent unauthorized copying and retransmission or trace violators of rights to the material. This point is returned to later during the discussion of the value of information.

Billing for information is not the only reason it is counted. Examples of non-accounting numerical tallies of information abound. Such tallies are used to summarize hits (visits to a webpage), numbers of customers communicated with, turnaround times for information requests, etc. Another numerical tally is the stock of information in a firm's "information warehouse" defined by Sheldon as "an entity that allows end users to quickly and easily access an organization's data in a consistent way" [Sheldon, 1998, p. 499]. Such tallies help management measure and evaluate information publishing and exchange activities. A stock measure of information would be the system's capacity at a given time, with flow measures being summaries of activity. On a broader philosophical basis, phrases such as the "stock of knowledge" apply as well.

Before discussing other conceptualizations, it is important to realize that each conceptualization of information may not have a direct economic role or a role in the human process of communication. For instance, the first conceptualization of information was important from the accounting and computer engineering design viewpoints. It has a direct economic role in pricing and an indirect role in internal and external cost structures. However, volume-based engineering measurements of information tend to ignore the data-information distinction (covered next) because the content of a message is not strictly relevant to the means of transmission.

2.4.2 Information Conceptualized as a Processed Resource or Raw Commodity

The next conceptualization considers information depending on whether it is an engineering or accounting description of carrier service, production input, intermediate product, or processed output. Within hypercommunications, this point is easily seen through the conceptual conflicts between information and data. From one standpoint, organizing, re-organizing, and processing information is a production process that uses inputs of data (or raw information) to yield an information output. Under this view, information is an economic resource that can be an input, output, or both. From an engineering standpoint, the term used to describe communication contents (whether called data or information) is not necessarily relevant. Instead, quantitative concepts such as the timely, speedy, and error free transmission of digitally-coded communications treat the transport of information as a commodity.

One source of such a distinction is whether a firm creates and sells information or simply carries data. To the information producer, there is an important difference between data and information, a distinction that is absent from the communications carrier's worldview. Students of behavioral and physical science are often told in introductory statistics texts [see, for example, Summers, Peters and Armstrong, 1985, p.2] that the terms data and information refer to different concepts. Data are "unorganized facts or figures from which conclusions can be inferred" [*Webster's New World Dictionary*, college ed., 1960, p.374]. Presumably, once those data are organized, the result is an output of information, a value-added product.

According to LaFrance the economist's role is itself based on the distinction between data and information:

> In an information age, it is increasingly important that we do not confuse data with information. Information is data which are placed within a particular context. It is the context and underlying conceptual framework that makes the data useful in decision making. Without the context and framework, the value of data is indeterminate. Agricultural economists are often the vital link in producing useful information out of data and defining what data are needed to produce information. Constructing a framework and establishing a context for data are what we do as economists . . . " [LaFrance, 1993, p.1]

Indeed, the data-information distinction is the purpose for having information workers in general.

To some hypercommunication firms, processed information itself is sold, as is the case for radio and TV broadcasters or membership-only websites. In such cases, information content is sold as a good or service. To other hypercommunication firms, the reliable and speedy transmission of digital content, together with communications capacity (bandwidth), are sold as services. It is possible that these distinctions will become less important as convergence occurs, but they currently are important philosophically and economically.

To hypercommunications carriers, the term "data communications" has not traditionally relied on any distinction between data and information, instead signifying digital (especially computer) communications. Now that voice, video, facsimile, and computer communications can all be carried by the same digital pipeline, "data communications is all about transmitting information from one device to another" [Sheldon, 1998, p.213]. To computer systems engineers, any distinction between information and data is unnecessary because the word data is used to signify digital communications services, to quantify throughput, and to charge customers based on distance or quantity in bits. Common use among hypercommunications carriers and computer vendors suggests that information and data are synonyms.

The requirement that data be "organized" in an engineering sense so they can be transmitted does not necessarily change those data into information in an economic or statistical sense. However, according to Novell in 1999, there is an engineering distinction between data and information. "Computer data is a series of electrical charges arranged in patterns to represent information... data refers to the form of the information (the electrical patterns). It is not the information itself. Information is data that has been decoded." [Novell, 1999, p.4]

The purpose of hypercommunications is to communicate information or data in many message types over a variety of channels and platforms. However, measures of hypercommunications volume and capacity are based on engineering models of communicating data. The value of information "bought" from a hypercommunications carrier to a firm depends on how processed the information is, the ultimate use, how efficiently information is obtained and hypercommunication services are used, and the producer's efficient provision of services. The conceptualization of information as a processed resource or raw commodity is part economic and part technical.

2.4.3 Information Conceptualized as a Perception of Pattern

A third conceptualization of information is as a "perception of pattern". According to Braman: "Information from this perspective has a past and a future, is affected by motive and other environmental and causative factors, and itself has effects." [Braman, 1989, p.238] Instead of counting bits or treating information as a homogenous commodity or input, the richness and meaning of content is considered. Information diffusion is a process (similar to the diffusion of innovation process, section 2.3.5) where information is exchanged within an organization or among consumers in a target market. Information literacy has to do with the human ability to find and evaluate useful information. Information processing refers to the psychological tasks people use to remember information and act on it. The combination of information processing, the process of information diffusion, and information literacy allow an organization to perceive information patterns so they can be used in problem solving.

The marketing literature ---see Assael [1992, pp. 488-520] for an overview ---has applied psychology to the role of information exchange across groups and to diffusion theory. There is often a diffusion process dependent on human individual and group behavior that weighs information before passing it along (or not) depending on perceived expected metaphysical and economic utility. There may be a physiological human limit to the speed of information processing, putting breaks on the rapid dissemination of information past an individual's threshold level. Additionally, information processing is another limit to the speed with which humans can sequentially process information before diffusion can occur.

If computer science models are projected onto human information processing and diffusion behavior without recognizing fundamentals of economics and marketing (which require perceptions of pattern), two simple mistakes can occur. First, the model can be mis-specified if economic behavior is modeled after immutable physical law. One example would be making a hypothesis based on Say's "law" in the same way a hypothesis would be based on Faraday's Law of the Electromagnetic Field. Supply of information does not create an instant demand for transmission of that information without an underlying behavioral need or market, any more than water boils at 212 degrees F. at sea level without heat.

Second, when economic models of new information technologies are chained to the methodology of the inanimate science that developed those technologies rather than human market behavior, a "trees grow to the sky mentality" can arise. Markets can have what Alan Greenspan has called an "irrational exuberance" about information technology's ability to exponentially increase sales and profits, leading to overly ambitious projections of an exponentially increasing information base, and exponentially rising economic benefits as a result. Engineering-based models tend to ignore human and economic constraints on such things as the speed of technology adoption, rate of growth in information processing, and the scarcity of attention.

Growth models that rely on computer science parameters for hypercommunications could end up with huge prediction errors of the future total if they assume that annual growth rates in information industries will continue to be forty percent compounded continuously.[17] Even if information and data flow at faster and faster rates over fatter and fatter pipes *ad infinitum*, there are many reasons technological change outstrips human ability to change technologies. Information patterning is perhaps the central reason that human information processing and patterning cannot keep pace with engineering progress. Human literacy skills are learned more slowly than broadband networks of fiber optics can be laid. The additional brain pathways medical researchers have discovered the brain physiologically adds due to human exposure to informational stimuli are chemically burned-in at a slower rate as well. There is an enormous capacity for information-trained, information literate workers to improve their productivity. However, at some point even this information elite will be stretched to the limit ---if it already is not, given the norm of sixty-hour work weeks and positions left unfilled due to a lack of qualified candidates.

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[17] Some proprietary models of Internet stock valuation go further --- they assume that the growth rate *itself* will grow at an increasing rate. Not only will the growth rate be everywhere positive, so will the second derivative. Because the economy is in transition from a manufacturing economy to an information economy there is no limit to the possibilities according to apologists for hypercommunications stocks that quintupled two years in a row during 1998 and 1999. See Frederick Lewis Allen's (1961) story of pre-depression era America for similar valuation arguments from analysts seventy years ago in the bull market of the late 1920's led partly by exuberance about the possibilities of radio and electricity.

Not all information transmitted through a hypercommunications network is actually communicated,[18] partly due to human inability to absorb exponentially increasing information as rapidly as it can be transmitted. Information overload means the recipients of communicated information are unable to act on, much less process, excess quantities of information at once [Assael, 1982, p.167]. Furthermore, the rate of information diffusion, another part of the communications process, depends on social interaction, educational level, attention, and other factors.

The field of attentional economics is particularly important here. Arrow once wrote "information exchange is costly not so much because it is hard to transmit but because it is difficult to receive" [Arrow, 1975, p.18]. An area of economics called attentional economics originally from the psychology literature [Thorngate, 1988, 1990, 1997] considers the scarcity of time within the context of seemingly unlimited information. Thorngate contends there is

> . . . a fundamental error in discussions of the information economy. All economies are based on some form of scarcity, but there is no scarcity of information in the world. Instead, there is a scarcity of time to "spend" and attention to "pay" for the information available. . . . It is the scarce commodity that defines an economy of attention governing the relationship between information produced and information consumed.

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[18] Engineers are sometimes tempted to think that all information received by a device is also received by users. The Internet is an engineering marvel that is now getting to know the less idealistic cyberworld of e-commerce economics. However, the Internet was not designed with economic or marketing motives. Now, the engineers are busy with the Y2K bug, viruses, electronic signatures, and fighting spam. In spite of their recent bullishness on technology, they were unable years ago to see technology's positive and negative impacts resulting from economic behavior.

> Enter the Internet. Its low cost, ease of use, high speed, and reliability make the Internet almost perfectly suited to those of us who spend so much of our time producing and consuming information. Therein lies the fundamental dilemma of an attentional economy. Because the Internet is such a good way to distribute and exchange information, we are increasingly using it for these purposes. Information thus proliferates at an increasing rate. Yet, our time remains constant. As a result, the limits of our time force us to pay less attention to more information. By distributing more information more widely, more quickly, and cheaply, the Internet intensifies an already fierce competition for our limited resource. [Thorngate, 1997, p.296]

Processed information is typically more valuable than mere data or unprocessed information. Information becomes valuable through organization, categorization, analysis, and other information processing activities. In this sense, IT processes information for problem solving.

It is from the conceptualization of information as a heterogeneous, behavioral input to be processed into a recognizable pattern and diffused through a firm, that the relevance of information literacy skills arises. The American Library Association gives information literacy this definition:

> To be information literate an individual must recognise when information is needed and have the ability to locate, evaluate, and use effectively the information needed . . . Ultimately information literate people are those who have learned how to learn. They know how to learn because they know how information is organised, how to find information, and how to use information in such a way that others can learn from them [American Library Association, 1989 as quoted in Dupuis, 1997, p. 98]

An important implication of information literacy is that differences in the ability to deal with information are important explanations of variation in human capital [Shultz, 1975].

Another implication of information literacy is that there will be less reliance on the standard broadcast, newspaper, and Extension Service "gatekeepers" to control and filter information and bring it to general attention. The role of such gatekeepers could be substantially weakened in an Internet society where everyone can read, see, and hear the information they want without centralized editorial filtering. For example, Linoberger and Gwin (1982) identified behavioral barriers suppliers of technology will face if they seek to "extend" the technology to customers in production agriculture, agribusiness, and rural communities.

Linoberger and Gwin also recognized that the diffusion of information depends on a system of public and private organizations working on innovation, dissemination, and integration. The amount of new information about new technologies that can be transmitted depends on the number of "change agents". As the base population of information literate firms and individuals becomes larger, so will the speed of innovation increase within agriculture. Limitations on the increase depend on public and private infrastructure investment, stickiness of adoption and diffusion behavior, and markets.

In addition to the Extension Service publications of agriculture, pre-Internet society had newspaper editors, TV news assignment editors, and others whose job it was to decide what was and was not news. This helped to protect the public from information overload and sell advertising. Information literate audiences may prefer to find and filter information for themselves rather than trust experts. However, because there is information from more sources and in much greater quantity, greater editorial control of information rather than less (with costs offset by advertising) may occur. As Linoberger and Gwin suggest:

> . . . we must remember that no matter how sophisticated the equipment is, it exists to serve people's needs. We must still involve the audience in planning uses that fit their needs. They must help frame the questions and develop programs, if the tool is to be useful in the real world. [Lionberger and Gwin, 1982, p. 191]

A new title, the CIO (Chief Information Officer) is becoming common in large agribusinesses to accomplish the gatekeeper and filtering tasks among others [Boar, 1993]. In essence, agribusinesses have their own internal Extension Service staffed by MIS personnel, web designers and programmers, and call center staff. This is supported by Wu *et al.* who argue that larger organizations require highly trained information users to serve as intermediaries or gatekeepers and process public information to bring specialized information to specific end-users within the firm. Smaller organizations might use a consultant to accomplish the same purpose.

Rather than "drive private information sources out of business", government information "makes their role economically viable" because the sheer volume of information and its complexity requires that specialists serve as the new gatekeepers [Wu, *et al.*, 1999, p. 12]. Instead of using outsiders (such as newspaper editors or Extension Agents) as gatekeepers, the new gatekeepers for firms are insiders who act as transducers for *inter-firm* information; a boundary scanner is the transducer for *intra-firm* information [Afuah, 1998, p.37].

2.4.4 Major Economic Properties of Information

According to Varian, "The most rapidly growing area in economic theory in the last decade has been in the area of information economics." [1992, p. 440] This economics worldview was brought about partly by Stigler's seminal paper on the economics of information (1961) which built on the work of Ozga (1960). These arguments were extended by authors such as Colantini (1965) and Grossman and Stiglitz (1980) as well as with concepts such as the efficient markets hypothesis [Fama, 1970].

Fama (1970) named three forms of efficient markets. Kolb provides a thumbnail sketch of them:

> The weak form of the efficient markets hypothesis claims that prices in a market fully reflect all information in the history of volume and price. The semi-strong version claims that market prices fully reflect all publicly available information. The strong version states that market prices reflect all available information, whether public or private. Private information includes information possessed only by corporate insiders and government officials. [Kolb, 1990, p.168]

From this work, two major economic properties of information are derived. The first concerns the value of information and the second concerns information search costs. These will be followed with separate sub-sections concerning the treatment of information as public good (2.4.5), asymmetric information, 2.4.6, and other economic properties of information (2.4.7).

Perhaps the most basic economic property of information is the attachment of value to that information. Valuation of information comes from several sources. It helps to decompose value into seven elements. Based on review work from several disciplines (economics, marketing, sociology, and psychology) Sheth, Newman, and Gross [1991] synthesized value into five components: functional value, social value, emotional value, epistemic value, and conditional value. To these five are added two additional components from resources economics, option value and existence value. Each component suggests conditions under which seemingly intangible benefits or costs of a good or service (such as information) may show up in observed market prices. An understanding of these seven components of value explicitly recognizes *how* information may have value.

Functional value has always been in the economist's domain. Functional value is defined as value in use or exchange resulting from utility maximization. Proponents of economic psychology argue that utility maximization is not the sole determinant of choice. Katona [1951,1953,1963,1975] argued that utility maximization depends on sentiments and subjective expectations so that psychological reality may determine choice under some circumstances rather than price alone. Functional value and utility maximization may still dominate choice under assumptions of perfect information, but the remaining sources of value play an important role in determining utility.

According to Sheth, Newman, and Gross, the social value of a good is derived from its association with one or more distinctive social groups. Thorstein Veblen's conspicuous consumption hypothesis, Katona's fun and comfort needs, and the idea of social class are examples of sources of social value. Social value (used in this sense) could be called sociological value to avoid confusion with "social" cost-benefit accounting in economics.

Information is especially affected by two areas within the framework of social value. First, reference groups may play a role in information consumption. Group pressure to conform may be especially important. For example, the corporate culture of a firm may play an important role in the volume and quality of information the firm uses or buys. Second, opinion leadership is known to play a significant role in the transmission of information. For example, opinion leaders (people who have more exposure to information than others) intervene between the mass media and the opinions and choices of others. The cholesterol information index (Brown and Schrader 1990) is an example of an application of opinion leadership to the problem of food safety. Brown and Schrader assumed that physicians were opinion leaders for their patients in giving advice about healthy, safe foods when they used medical journal articles about cholesterol as a proxy for information.

Emotional value, a third component of value, is covered by a broad range of research in psychology and marketing. The roles of personality, psychological health, and other individual attributes help to form the emotional value of information. Here, the main importance regarding information may rest in the areas of fear of information technology, the individual psychology of information overload, and the role of personality in information literacy.

Epistemic value is considered to come from the capacity of a good to arouse curiosity, or satisfy novelty-seeking or knowledge-seeking objectives. Consumption of information, information-gathering activities (such as web surfing and research), and communication of ideas about new information provide epistemic value for individuals in search of novelty or knowledge.

Sichel and Eckstein (1974) explain the importance of epistemic value in economics:

> Diminishing marginal utility is an expression of the 'variety is the spice of life' philosophy of most individuals --- that people prefer to have one or a few of a lot of different goods and services rather than a great many of only a few goods and services. [Sichel and Eckstein, 1974, pp. 128-129]

The combination of information and epistemic value has important economic implications. In addition to the increased well being of the novelty or knowledge seeker, there can be effects on demands for goods other than information because of exposure to information. For possibly dangerous goods, safety information may serve to increase the epistemic value of substitute goods. Consumers may want to learn more about computer security software, for example, because of exposure to information about the danger of viruses.

A fifth consumption value is conditional value. According to Sheth, Newman, and Gross, "The conditional value of an alternative is derived from its capacity to provide temporary functional or social value in the context of a specific and transient set of circumstances." Ice cream on a hot day is often used as the classic example. The timing of information can clearly influence its conditional value as in the case of a firm that misses orders from consumers who need product in a hurry. Seasonal demands for many types of information may be based in part on their conditional value.

The last two components of value are from the resources economics literature. According to Pearce and Turner (1990), "Total economic value = Actual use value + Option value + Existence value." [Pearce and Turner, 1990, p. 131] Actual use value is embodied in the five sources of consumption value already discussed.

Existence value covers cases when there is value for the existence of something (such as a wilderness area or other public good), whether or not the economic agent doing the valuation will ever derive any benefit from visiting the wilderness. In essence, existence value is "unrelated to any actual or potential use of the good" [Pearce and Turner, 1990, p. 134]. For some firms, the mere existence of a web site or information data bank has existence value as well, regardless of any actual or potential use. Pearce and Taylor admit, "existence values are certainly fuzzy values" for which "it is not clear how they are best defined" [Pearce and Taylor, 1990, p. 131].

While the motive behind existence value in the natural resources literature tends to be altruistic or sympathetic, this need not be the case for information to have existence value. There may be feelings of safety and security that come from the existence of some kinds of information. Sympathy for the so-called "digital gap" between information "haves" and "have-nots", for example, is used as a justification for various policy levers. Further, concerning electronic privacy, there may be an existence value to *not* having certain information about oneself made public over the Internet, etc.

Finally, option value captures the bequest and gift motives of future consumption, along with vicarious value obtained by someone else's use. "The Quasi Option Value (QOV) is the value for preserving options for future use given some expectation in the growth of future knowledge." [Pearce and Taylor, 1990, p. 134] The willingness to pay for information that might help a firm in the future would be an example. Hypercommunication redundancy is another example, where a second telephone or Internet provider is selected as a backup that may never be used.

Information's value must be balanced against its cost. Roger Noll mentions in 1996 that there is a balance to information value between information producers and consumers.

> Putting barriers between potential users and the creator of the information is to limit the degree to which economic value will be derived from it. The other side of this dilemma is that, if no mechanism is in place for the inventors, or producers, or publishers, or disseminators, of the new information to recapture their costs, then people will not produce as much information as is socially desirable. [Noll, 1996, p. 39]

An additional point about the cost of information Noll makes is related to hypercommunication technologies. He notes that many of the "first copy" costs of publishing scientific journal articles, for example, are "independent of the medium" [Noll, 1996, p. 41]. Yet, "other kinds of fancy electronic publication possibilities vastly reduce the cost compared to print" [Noll, 1996, p. 41]

In conventional economic demand models (whether consumer or business-to-business), the assumption is that all parties possess some kind of information parity. Should the seller, buyer, or both have "limited" information about pricing, quality, or competitors, the full information assumption must be relaxed and uncertainty results. Information is said to be asymmetric in such cases because the amount or quality of one economic agent's information is greater than another's. Stigler's contribution initially came from his recognition that information seeking is not a costless activity. Baumol and Blinder summarize and extend the point:

> Neither firms nor consumers have complete information because it would be irrational for them to spend the enormous amounts needed to get it. As always, the optimum is a compromise. One should, ideally, stop buying information at the point where the marginal utility of further information is no greater than its marginal cost. With this amount of information, the business executive or the consumer is able to make what have been referred to as 'optimally imperfect' decisions. [Baumol and Blinder, 1991, p.621]

However, it is not necessarily patently obvious to a business executive or consumer how much information should be purchased with available time or money. Often, an individual will rely on an agent for information, leading to a possible principal-agent problem.

Though hypercommunication allows firms to gather more information at much lower fixed and variable costs than ever before, there are new costs involved. Labor costs, such as those needed to train or hire information literate workers may actually be higher in the information age. Certainly, both relative and absolute costs of communicating and processing information have fallen in many ways. However, the tradeoff between costs and benefits of information is probably even more important now than ever before. Furthermore, the quality or competitive superiority of information rather than the quantity is most important economically.

2.4.5 Information as a Public Good

The degree to which information is a public good is central to its economic role. It is a matter of degree instead of a binary state as Lamberton points out:

> "The answer will depend on whether we are dealing with all purpose information or are being more practical, recognizing that there are many kinds of information. [Lamberton, 1996, p. xxiv]

It has, he goes on, "traditionally been regarded as a public good" because it is indivisible, non-rival, and non-excludable [Lamberton, 1996, p. xxiv].

However, unlike, air or national defense information has weightless, idiosyncratic characteristics as Macdonald (1992) states:

> Information is different from other economic goods; unlike them it cannot be displayed to a potential buyer, otherwise he will possess without having to buy. So those who buy information are always uncertain of precisely what it is they are buying. So imperfect is the market for information that price alone may determine demand, with information unwanted when it is sold cheaply and the same information in much demand when it is expensive. Consultants may sell a report much more easily than academics may give away the same report. Exclusivity generally increases the value of information to the buyer, but as information may be reproduced at little cost and always remain with the seller anyway, exclusivity can be hard to guarantee…information tends to be of little use in isolation; the buyer seeks to purchase only that information which is

> compatible with that he already has...information itself may be a non-perishable good, but its value to many customers tends to be extremely time sensitive. [Macdonald, 1992, p. 55]

In agriculture, for example, both weather forecasts and crop reports are examples of information that is a public good. If a Florida citrus processor downloads weather forecasts from the NWS (National Weather Service) website, that does not prevent a New York futures trader from doing the same. In that sense, the weather information is non-rival; the citrus processor's use of the information does not prevent the futures trader from using it also. One of the characteristics of a public good is non-rivalry.

Another characteristic is the non-excludability, or the fact that the NWS cannot control how the weather information is used or who uses it. Hypercommunications allow such information to be distributed to a larger audience and gathered from a wider number of sources, for a lower variable cost than in the pre-convergence world of hypocommunications. Furthermore, public discussion of such information on Internet newsgroups, for example, can also help individuals weigh the value of existing information.

Information literacy skills allow raw information such as weather forecasts (a public good) to be more efficiently transferred into proprietary market intelligence (a private good) subject to behavioral constraints of processing and diffusion.[19] Information literacy skills within a firm's labor force allow the information processing task to be internalized, so that the firm can substitute cheap access to information for costly purchased information inputs.

Information that has been processed using information literacy skills (especially as part of a business' information processing strategy) is excludable and hence a private good. See Porter and Millar (1985) for an early example of strategic implications for firms. For example, if weather data are reported on the citrus processor's website and re-arranged by crop region or county, they have been processed but in a cursory and non-excludable way. Suppose the futures brokerage employs an information super-literate who correlates National Weather Service data with ENSO (El Niño) data to form a statistical model of freeze damage that accurately predicts prices. Then, the information processing yields an excludable set of information (temporarily). Unless the citrus processor is given or sold the results of the model (together with their interpretation), he is excluded. It makes no difference if all of the raw data was obtained essentially at no charge from the Internet by both organizations. Even if both organizations used hypercommunication services to access the data and computers to process it, only one used information literacy to create a private information "good" from public good inputs. However, this advantage can be short lived, depending on the form of market efficiency.

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[19] The length of time that information remains a private good may be very short of course. Under the strong form of the efficient markets hypothesis, even private "inside" information is instantly reflected in market price, so many economists doubt that the futures brokerage (or especially individual clients) would systematically benefit from the "private good". If we assume that the firm would temporarily benefit by payments from clients for research reports, the information would have value ---though only until those clients discussed or acted on the information.

Note that there is little difference between the weather information example and the definition of technology itself, except for one detail. IT and hypercommunications technology were used to gather and process information and add value to it. It could be said that the difference between information and technology depends on context. For example, hypercommunication technologies may deliver an information input that is scientifically unrelated to agribusiness, for example. However, better hypercommunications technology allows the agribusiness to enlarge its production set or market more efficiently using agricultural sciences.

2.4.6 Asymmetric Information

Inherent to the excludability of information is the asymmetry of information, or "situations where one economic agent knows something that another economic agent doesn't" [Varian, 1992, p.440]. In a two-agent situation, there are four cases: both parties have limited information, the seller alone has limited information, the buyer alone has limited information, or both parties have full information. Theory suggests that information can provide competitive advantages and even a high degree of market power. Such advantages depend on numerous factors and may tend to be short lived [Carlton and Perloff, 1994].

One reason protocols and standards in hypercommunications (as well as grades and standards in agriculture) exist is to protect an inherently weaker party to a market transaction from fraud due to asymmetric information. Specific examples of how such standards work will be found in 4.5.2.

Note that asymmetric information does not necessarily convey asymmetry in bandwidth (more precisely, data rate) or *vice versa*. The term asymmetry is used two ways in hypercommunications. First, to identify the degree to which a given call or session is two-way (as in synchronous or asynchronous circuits). For example, most pagers currently on the market are strictly one-way, receiving rather than transmitting information. Many telephone calls such as those on most speakerphones do not allow parties at each end of the conversation to speak at once or continuously interrupt (as in full duplex, half-duplex, or simplex hardware). Second, asymmetry for hypercommunications carriers depends on whether download and upload bandwidths are equal. So-called 56k modems have a download capacity of 56 kbps, but an upload capacity of 33 kbps.

It may be that companies achieve a degree of market power on the WWW (World Wide Web), for instance, depending on the interactivity and capacity of their websites. A dynamic or visually spectacular website one usually requires the transmission of more text and binary content to viewers than a static one does. However, site viewers *send* approximately the same number of characters regardless of whether they *receive* plain text or high-resolution graphics. Hence, web designers face a tradeoff between using high-bandwidth sound, images, and video and the reality that a sizable proportion of web surfers have download speeds of 56 kbps or less. Hence, the information itself may or may not be asymmetric, but the transmission is. However, this technical asymmetry can lead to information asymmetry.

In addition to the transmission context, asymmetric information can have important economic repercussions for hypercommunications sellers with far better information than their customers or competitors about services, technologies, and system reliability. Hypercommunications pricing depends on the economic asymmetry of information at least as much as it does on asymmetry of information in a bandwidth sense. The sheer complexity of services, technologies, options, and pricing plans can give a hypercommunication supplier a considerable edge over the buyer. This point is revisited during the discussion of unlimited complexity in 2.5.2. Comparison-shopping is hindered through bundling and unbundling of services, and by price policies that vary from metered to measured to unlimited access.

2.4.7 Other Economic Properties of Information

Information has several other important economic properties. First, information has value in reducing risk or uncertainty that depends on the risk aversion of firms. Information has several properties that reflect on all the conceptualizations of information given. First, for agribusiness, the value of information is related to its use in reducing uncertainty in the decision-making process. (FAO, 1986, p. 42) Three kinds of information are usually named: normative, positive, and prescriptive. Normative information reflects values and social norms to yield what "should" be done from a right-wrong continuum of beliefs. A second type, positive information, is meant to be an objective representation of facts, conditions, and other factors independent of any moral imprimatur. A third kind, prescriptive information, uses both normative and positive information to arrive at a prescription or decision via decision rules. Decision rules such as compromise, consensus, laws, and physical coercion combine with imperfect positive and normative information to yield prescriptive information that guides decision-makers.

Second, information's use in organizational decision making is closely related to horizontal and vertical integration, organizational shape, and organizational form. Focuses of individual agents tend to be narrow, such as personally obtained knowledge of available communications options, instead relying on a group or team approach (in business) that could create principal-agent problems. The principal or corporate executive in charge of hypercommunications often relies heavily on advice from agents representing competing interests within the company or agents outside the firm.

For example, a web site, domain name, and ISP may be seen differently by the marketing department compared to the vision conceived of by the MIS department. There is considerable risk that technology will be employed inefficiently and/or ineffectively if participants have conflicting objectives, unequal information, or are not all stakeholders in the outcome. However, this may be simple specialization because as Baumol and Blinder admit:

> Obviously, if participants in the market are ill-informed, they will not always make the optimal theoretical decisions described in our theoretical models.
>
> Yet, not all economists agree that imperfect information is really a market failure. They point out that information, too, is a commodity that costs money to produce. Neither firms nor consumers have complete information because it would be irrational for them to spend the enormous amounts needed to get it. (Baumol and Blinder, 1991, p. 621)

Therefore, seemingly narrow focuses of individual agents may be evidence of properly functioning markets rather than proof of market failure due to asymmetric information.

A third economic property of information is more insidious because it becomes the prize in a zero-sum game, but without one party knowing the rules of the game or that they have lost personal information to the "winner". For example, customer profiles (including the "cookies" that surreptitiously gather information about each computer household in an audience) are one way of avoiding respondent burden and customizing information, but at a possibly invasive cost if "spammers" use cookie data. Therefore, security, privacy, source credibility and information overload may become more important issues than ever before, as will the technological literacy of the public. Information may have plainly or hidden negative value in many cases brought about as the hypercommunications model replaces the interpersonal and mass models.

2.5 The Frontier of "Unlimited" Communication

Librarian of Congress emeritus Daniel J. Boorstin was asked in 1997 to name the ten leading ideas of the second millennium that have shaped Western civilization and world history. The ninth of these, "unlimited communication", he describes as:

> ...beginning with printing and the rise of literacy (since the 15th century) and electronic communication (since the 20th century). Reliance on greater communication, leading to a more universal awareness of the human condition, problems, and opportunities. [Boorstin, 1997, p. 33]

It would not be difficult to cite other, more excited proclamations that hypercommunications is ushering in a new cyber frontier with the possibility for greater wealth and welfare worldwide. However, the implications of the new cyber frontier of unlimited communication are not typically broken down for agribusiness.

The section has two parts. First, there is a discussion of the differences and similarities between the unlimited frontier of communication and information and the historical experience with land as a productive factor in agriculture (2.5.1). Second, other aspects of unlimited communication (of a distinctly limited nature) are covered (2.5.2).

2.5.1 Unlimited Frontiers: Land vs. IT

Assume that more is better (up to a saturation point) when it comes to being able to communicate. If hypercommunications market prices fall low enough to enable "unlimited communication" *relative* to the present, it could mean society's knowledge base would grow at an ever-increasing rate. However, unlimited communication can be an unlimited bad if individuals and businesses are bombarded with telemarketing calls, spam, and security problems such as viruses, privacy intrusions, and identity theft.

The popular press is full of hype about the unlimited possibilities of the information economy. However, whenever economists hear a term like unlimited, it becomes more than an academic question as to how to evaluate the unlimitedness of something to find constraints. After all, if the astronomers are right and there is a finite end to the Universe, it would seem as though everything has a limit. However, limitations on information, human knowledge, wisdom, and technology do not come from physical science textbooks in neat mathematical form as they perhaps could in astronomy. Many argue that the mind is limitless judged in comparison to the physical plants of the previous manufacturing age. Yet, the information age has limitations. While these limitations are different (albeit more elastic than those of the industrial or manufacturing economy), the weightless information economy still has them.

Agricultural economists are particularly suspicious of claims of an unlimited frontier, because of America's historical experience with land. Indeed, the historical comparison between the (land) frontier and the cyber frontier is instructive. As the United States went from independence through the Civil War and beyond, it seemed as if land and natural resources were unlimited. The United States had an agricultural frontier from colonial days up until World war I. Much of the economic growth seen by the United States from 1800 until 1900 was simply due to the bringing of new land into cultivation. According to Hughes, "Until 1910, it was increased land input with a fairly constant yield per acre that enabled the great growth of Northern agriculture to occur." [Hughes, 1990, pp. 287] Eventually, the settlement of marginal areas showed economists that agricultural output could not increase at a faster rate than new acreage was brought into production. Agricultural productivity increased when Vermont farmland was abandoned in favor of Iowa land [Hughes, 1990, p. 287], but once settlement occurred on the marginal "unlimited" frontier lands of the western plains, the average productivity of (unlimited) land began to fall. Therefore, parts of the country were not settled, not because the pioneers somehow missed them, but because the cost of producing crops on new land was greater than the economic value of the expected profit stream.

Coincident with the early 1920's was a major recession that seriously plagued many agricultural areas of the country, with a few notable exceptions ---those lands that were still frontiers. Florida was one such place then, a frontier boom land. A warm climate and large supply of vacant land suggested that productive new areas were ripe to be opened up for agriculture. According to land sales claims, the possibilities were (locally) unlimited. Florida began the decade with 968,000 inhabitants, with over 60 percent of the population in rural areas (un-incorporated places or incorporated ones with under 2,500 people). Had the speculative "land bubble" of the 1920's (which caused over-valued Florida real-estate prices to plunge) not burst, population growth might have exceeded the half million new Floridians added to the state's ranks in the 1920's [Marth and Marth, 1992, pp. 50-51]. Because of the historical experiences with the western frontier and Florida in the 1920's, it is hard to conceive of a truly unlimited frontier.

However, unlimited communication may be entirely different economically from the familiar agricultural production problem in that new land and new technology differ. As new, previously un-farmed land is brought into production, agricultural output rises, but at some point, the cost of farming new acreage is greater than the profit it will bring. This point is where the "unlimited" land frontier faces a binding economic constraint. However, unlimited communication and the cyber frontier are different because:

> First, the accumulation of an intangible such as knowledge is not subject to any physical bounds. Moreover, there is nothing in the historical evidence to suggest that humans are exhausting the potential for advancing knowledge. [Grossman and Helpman, 1991, p.17]

Schumpeter [1943, p.118] wrote about how the cultivation and development of new land differs from the cultivation and development of new technology. With land, the best lands are taken first, leaving marginal acreage that is bound to run into diminishing returns. New technology differs Schumpeter argued because:

> ...we cannot reason in this fashion about the future possibilities of technological advance. From the fact that some of them have been exploited before others, it cannot be inferred that the former were more productive than the latter. And those that are still in the lap of the gods may be more or less productive than any that have thus far come within the range of observation. [Quoted in Grossman and Helpman, 1991, p.17]

Limitations on the information economy may not be conventional, but that does not imply that there are no limitations at all. Instead, physical, mental, and psychological obstacles to unlimited communication translate into limitations on economic behavior.

Increasing returns to scale are often seen as the source of the unlimitedness of communications and information technologies. As mentioned in section 2.3, increasing returns to scale is one reason the information economy seems to behave differently than the industrial economy. Often, however, far from being a source of unlimitedness, those returns are increasing only within some relevant range due to inevitable physical constraints. Varian (1986, p.319) supports this view:

> What would be an example of a technology that had increasing returns to scale? One nice example is that of an oil pipeline. If we double the diameter of a pipe, we use twice as much material, but the cross section of the pipe goes up by a factor of four. Thus, we will likely be able to pump more than twice as much oil through it.
>
> (Of course, we can't push this example too far. If we keep doubling the diameter of the pipe, it will eventually collapse of its own weight. Increasing returns to scale usually just applies over some range of output. (Varian, 1986, p.319)

Increasing returns to scale are traceable to the economics of networks, the non-conventional behavior non-rival inputs, and other aspects of "unlimited" communication. However, the very non-convexities they bring to production do not automatically translate into economies of scale in the same way that homogenous technologies would. The same goes for increasing returns to scope, span, and system. Economic limitations still occur when technological limitations do not appear to. However, as Leijonhufvud states, economists "lack a widely-accepted theory of pricing under increasing returns, lack a convincing model of how competition operates between firms with increasing returns, and lack a micro-founded theory of income distribution" for increasing returns as well [Leijonhufvud, 1989].

The next section takes this reliance on unlimited communication further by showing how popular myths of an unlimited cyber age do not mean the end of economic limitations. Even if communication has reached an unlimited frontier due to technology, the information economy is subject to constraints that stem from human economic behavior.

2.5.2 Other Aspects of "Unlimited" Communication

The information economy and communications may seem unlimited but each has many limiting factors. This section will discuss six limitations to unlimited communication that are (or are likely to become) binding economic or technical constraints: unlimited data through boundless bandwidth, unlimited complexity, limited audience, limiting geography, unlimited time through compressed time, and limited time. Each could slow the speed of unlimited communication.

2.5.2.1 Unlimited data through boundless bandwidth

In science and in business, there has long been a difference between information and data. An analogy might be mineral exploration where the copper (information) was mined from the ore (data). There is great value in the exchange of information, assuming at least semi-strong form efficient markets (Fama, 1970). However, just like a mine operator in an El Niño year, a firm can be buried in an information overload, just as easily as an overload of water that floods tunnels and suspends production. Just as an individual user may become bogged down in a morass of un-read, un-answered e-mail, so too an e-agribusiness can be buried in un-answered, un-answerable, misrouted, waylaid, or intercepted e-mail. This can be true of any form of hypercommunication messages, but it is most clearly seen in the Internet context.

This point reintroduces the idea of attentional economics along with logistical and attitudinal challenges. A Florida farm, ranch, or rural organization may try to use the Internet to communicate very cheaply in personalized detail with their current customer base, suppliers, employees, or potential customers. However, the organization must be ready and willing to answer e-mail (at least to acknowledge receipt of the message) instantly if possible. The rapidity of response will depend on the nature of the business. An agribusinessperson can now call, e-mail, or fax clients from home, office, sod farm or golf course. However, he or she may use technology to "screen" increasingly annoying communication interruptions and avoid interpersonal contact, thus annoying customers.

Much hypercommunication centers on an open architecture's free inflow and outflow of data. Unlike a physical ruby mine where guards can be posted to prevent intruders and thieves, valuable information travels over bandwidth in fibers and through spectra without a foolproof way to guard gems of information. Unlike excludable precious gems, however, stolen information does not have to vanish from a vault for the theft to have occurred. Hence, it can be possible for theft to occur without the owner's knowledge.

Unlimited data also result in vast flows of unwanted or unneeded information. It is almost costless for a marketer to "spam" us, set a "cookie" up, or for hackers to crash a communication network. Not everyone wishes to see Playboy TV or the Trinity Broadcasting Network. They can try to filter out the noise or demand that their carrier or government do so. However, generally, if a firm wants the benefits of information, it must pay the cost of filtering it and securing its value. The unlimited data phenomenon is one result that filtering seeks to avoid. Only knowledgeable customers, government agencies, or protocols can reduce the risks to firms that connect to an ISP.

As the price of delivering bits of data falls and technology increases the available bandwidth that carries the data, it appears as though bandwidth is boundless. However, filtering and security require that limits be placed on hypercommunication even if it is technically possible for super exponential growth to continue. Just as in ordinary personal communication, a reasonable person would be expected by economic theory to behave in a guarded manner. However, the degree of guardedness is a tradeoff between costs and benefits.

2.5.2.2 Unlimited complexity

Northern Telecom's memorable waitress series of television commercials illustrate the complexity of converged technologies or "Power Networks" in Nortel's parlance. Power networking is inherently difficult to comprehend because it is the technologically complicated merging of voice calls, data networks, Internet traffic, e-mail messages, and other services. The commercials depict hard-pressed corporate decision-makers at a diner. When one of the young business people admits to confusion, a waitress knowledgeably discusses fine points of power networking in dense jargon, taking her customers' breaths away. In fact, Nortel's definition of power networking is an operational definition of hypercommunications:

> Power Networks extend beyond the integrated wide area network to include an organization's call centers, the Internet, intranets, enterprise mobility, multimedia communications applications, and telephony environments. With Power Networks, these applications, and the rest of an organization's communications infrastructure, are holistically integrated to improve business performance. Companies can no longer afford to configure and implement these technologies independent of each other. [Nortel, 1997].

However, this is not an inherently simple "make or buy" business decision. With such a variety of terminology, jargon, and especially, acronyms, the assumption of basic technology literacy on the part of both consumers and producers can be questionable.

Hypercommunications transactions often occur in spite of the fact that neither the buyer nor the seller is completely familiar with every aspect of services and technologies. Yet, there is often universal feigned understanding. There can be an embarrassment cost or risk of job loss from appearing not to know what a particular term means. There can be confusion due to asymmetric definitions of terms, or based on differences in values, beliefs, expectations, educational level, or age group.

Many terms have multiple definitions to emphasize that most (if not all) hypercommunications words have at least two operational definitions. For many terms, there is one set of definitions in print, another circulating in cyberspace, and still another set under various stages of proprietary research and development. Furthermore, the definitions are not all frozen in time or scope even if a transaction's contract is. Frequently, old meanings are used for hypercommunications words with evolving new potential.

As with any complex product or service, however, the market is able to function without each agent having a full and complete knowledge of the inner workings of the tiniest technical mechanism. Frequently, however, one better informed market player is able to use information and knowledge about such inner workings to his advantage over some time. The degree and duration of such an information advantage depends itself on how the underlying market is defined.

An important source of complexity comes simply from sheer communications volume. Whittaker and Sidner (1997) studied business e-mail users. They found that e-mail was used for more tasks than communications alone, noting that task management and personal archiving were particularly important unexpected tasks of e-mail in business settings. The term e-mail overload describes non-communications functions of e-mail:

> . . . E-mail overload creates problems for personal information management: Users often have cluttered inboxes containing hundreds of messages, including outstanding tasks, partially read documents, and conversational threads. Furthermore, user attempts to rationalize their inboxes by filing are often unsuccessful, with the consequence that important messages get overlooked, or "lost" in archives. [Whittaker and Sidner, 1997, p. 277]

In the study, inboxes comprised 53% of total e-mail files, with the mean number of inbox items at 2,482 with an average of only 858 "filed" items [Whittaker and Sidner, 1997, p. 281]. Filing is hard for people because they cannot remember where information is filed.

Thus, unlimited complexity can also be a source of unlimited headache. Software and hardware crashes and e-mail overload are but the tip of the iceberg. Firms may have to re-train employees as new technologies are added to keep up with increasing communication volume, losing valuable time. Switching costs include the length it may take to learn how use new services or to operate new software or hardware, as well as lost revenue due to technical and human glitches that alienate customers.

2.5.2.3 Limited Audience

To have unlimited communications, even if state-of-the-art hypercommunication technologies offer an unlimited number of ways to communicate, there must be an unlimited need to communicate. Often, commentators are swept up by excitement about the tremendous positive impact of technology that they forget about impediments to widespread adoption of new technologies. Many of these such as attitude toward technological change, aptitude for learning new skills, and the time it takes to diffuse innovation have already been covered. These presuppose that there "should" be a present or future demand.

Even if these limiting factors are removed, unlimited communications face a limited audience. The audience is limited by population, infrastructure access, language, attention, attention span, educational level, and a host of other factors.

2.5.2.4 Limiting geography

A fourth point concerns the inequitable geographical distribution of new hypercommunication technologies. This can occur because of regulatory barriers, regulatory inducements, and a variety of short-run adjustment mechanisms. Most importantly, the geographical distribution of new technologies depends on the actions of suppliers based upon the cost of infrastructure upgrades. Infrastructure penetration will also affect land prices and the rate of transition from agricultural to urban use in Florida.

In parts of urban and suburban Florida, firms such as BellSouth, GTE-Bell Atlantic, AT&T-MediaOne-Roadrunner, Time Warner, and Sprint offer a variety of hypercommunication services ranging from cable television to local telephone service to high-speed Internet. But BellSouth and Florida's other ILECs (Incumbent Local Exchange Companies) are prohibited by federal and state regulators from offering some services their competitors are permitted to provide over the ILEC's existing wire and switching networks. Currently, fewer than twenty percent of COs have DSL statewide and less than 0.5 percent of cable customers have fiber optic lines.

A high-speed hypercommunications infrastructure may never reach parts of rural Florida unless land use changes to residential development because a greater population density may be needed to cover the fixed cost of developing service. For example, Disney's new small town of Celebration, Florida (located just south of Disneyworld in Osceola County) offers enough hypercommunications amenities that Yahoo! named it Florida's most wired small town. However, it is unique among smaller communities.

Two implications that are crucial for agriculture flow from the inequitable geographic distribution: land prices and transition of land from agriculture to urban and suburban uses. Hypercommunications availability is a land-related factor of production for agribusiness. In his *1958 Yearbook of Agriculture* article, "Oranges do not Grow in the North", Ronald L. Mighell wrote:

> ...farmland can be used for more different purposes than ever before. The properties inherent in the land are now less restrictive, and other resources determine oftener what the most economic use shall be. The characteristics of land nevertheless still set limits that influence the broad patterns of agriculture. The successful farmer is the one who learns how to cooperate with the natural and biological processes that are linked to land. [Mighell, 1958, p. 404]

Mighell then divided land's physical factors from its economic factors. One of those economic factors was "communication facilities".

Land can become more valuable with a high-speed hypercommunications infrastructure "to the curb". Land transition from production agriculture to urban uses could be particularly affected. The cost of holding the land in agriculture is already reduced because of advantageous tax treatment, but the value of land tends to appreciate due to infrastructure improvements. Hence, infrastructure improvements create a tradeoff between rising in real estate values and increases in the return per acre to agribusiness. If returns per acre rise faster than real estate values due to infrastructure improvement, farmland is more likely to remain in agriculture. However, this result is limited by the geographic extent of infrastructure development.

2.5.2.5 Unlimited time through compressed time

Another brake on unlimited communications is time. Time is a limiting factor although computer processing and hypercommunications connection speeds are faster than ever. There are still only 24 hours in a day. Regardless of how fast the information economy and the businesses inside it move technology cannot create extra hours, extra days, or extra years. New hours, minutes, and seconds are not created by a digital clock. However, information technologies perform tasks in seconds that previously took hours.

This introduces the concept of time compression. The ability to get more done in less time can shorten decision periods or the length of run, an important aspect of the influence of time on economics and *vice versa*. Recall Persky's 1983 discussion of four periodicities the VSR (where all inputs are fixed), the SR (where at least one is fixed), the LR (where all inputs vary) and the VLR (where technology alone varies). The length of run is often considered constant across firms and not influenced by technological change.

There are two economic implications of time compression. First, unlimited information (updated frequently) can give firms the ability to make better-informed decisions more quickly. Secondly, at the industry and macro level, time moves faster as the result of unlimited communication. Investment decisions are made more swiftly, inventories are managed in real-time, cash flows into and out of the firm can be faster, and delay -sensitive transaction costs fall.

For these reasons, a new method of measuring time, Internet years, (sometimes likened to dog years) can be thought of in recognition of these reasons. Perhaps the problem can be likened to the idea that dog years do not equal human years. Suppose that the fast-changing nature of the information age was recognized by a calendar change where one Internet year equals one-seventh of a regular year. Technology-savvy firms that used hypercommunications to their full advantage would be up to seven times faster to adjust to changes in technology relative to their time-retarded competitors. Then, the way firms plan, budget, and make decisions would be altered if their thinking replaced one decision period with seven decision periods (each with the importance of one old year). The firm would be subject to new discount rates and opportunity cost of growth based on compressed time returns to high technology.

An important question is how varying relative periodicities affect information asymmetry and empirical measurement. One example of this is seen in contract lock-in, a possible disadvantage for buyers in the market for bandwidth. Often, hypercommunications suppliers sell bandwidth only through annual or multi-annual contracts where unit rates fall as terms rise. By locking customers into a long-term contract (such as a three-year term), a carrier can use time compression and fast-changing market conditions to its advantage while the buyer cannot.

The impact will depend on whether service is priced on a metered, measured, or unlimited access basis. Buyers cannot adjust to sudden network bottlenecks by buying from another supplier unless they have a redundant hypercommunications provider. A buyer may be stuck with too much bandwidth but be forced to pay for unused amounts in a measured or unlimited access plan. Alternatively, a buyer may require more bandwidth than the measured plan allows and have to pay premium rates for a particular transmission, time of day, date, week, or month. Furthermore, a buyer may be unable to take advantage of cheaper, more efficient hypercommunication services due to the contractual arrangement or be unable to replace broken equipment with state-of-the art hardware if it is incompatible with the contracted carrier's network.

Time compression and relative differences in decision periods among firms or between markets can cause a phenomenon known as data interval bias [Bass and Leone, 1983; Vanhonacker, 1983; Bass and Leone, 1986; Kanetkar, Weinberg and Weiss, 1986]. Data interval bias refers to the fact that coefficients from empirical models such as the elasticity of demand depend on time aggregation and the periodicity or data interval. For example, a separate conceptual model exists for weekly, monthly, and quarterly demand [Pasour and Schrimper, 1965; Sexauer, 1977; Capps and Nayga, 1990]. However, along with aggregation issues, time compression adds the problem that recent periods are shorter in length than distant periods before aggregation.

The econometrics and marketing literature and practice traditionally were limited to several standard regression assumptions [Kennedy, 1993, pp. 1-9]. These include: linearity, unbiased intercept, disturbances have same variance and are uncorrelated (or the absence of heteroskedasticity and autocorellation), fixity in repeated samples, no exact linear relationship among independent variables (no multicollinearity), and adequate sample size to estimate. An explosion in recent literature has led to investigation of increasingly complex models that bolster and batter statistical theory but often follow Goodhart's Law (1978) to certain breakdown when put into practice. Time compression due to technological change could be modeled through acceleration in rate of change variables using a changing coefficients model while keeping traditional equivalent periods.

Theoretically, a built-in data interval bias can be found for exponential and population growth models, regional economic models, financial analyses, or economic cost-benefit analyses. Each of these requires equivalent time periods and a constant compounding or discount rate. Under time compression, either the length of data interval, the discount rate, or both would change over the period of analysis.

In a practical sense, when modeling hypercommunications, sources of data interval bias are easily found. First, time compression is associated with better, more timely information, the limit of which is "perfect" real-time information. Wholesale hypercommunications prices can change in continuous real-time, by the hour, day, or month, though retail sellers lock in prices using contracts. A measured of demand sensitivity to price could be hard to obtain. As the progression to a unified hypercommunications market continues, demand data from a variety of markets and periodicities could be needed. Since elasticities vary based on the data interval, the selection of the "best" interval for aggregation can be subjective since theory provides no rule. One rule-of-thumb is that the "best" period is the one that most closely corresponds to the decision period that has sufficient variation to produce useful or even estimable estimators [Hanssens, Parsons, and Schultz, 1990]. Empirical analyses will have to follow an array of changing products, firms, industries, pricing structures and measures in both time series and cross-sectional data due to rapid changes in the fast-paced hypercommunications market.

Agriculture is often seen as a unique sector for a number of time-related reasons: crop cycles, animal cycles, the relationship between storage and time, and shrinkage due to seasonal weather conditions. Hypercommunications bring another important set of time-related aspects. First, real-time information and control will allow farmers to track prices, weather, and field conditions more closely. Second, new technologies such as biotechnologies can be internalized faster. However, slow speeds of adoption in particular agribusinesses and lags in infrastructure deployment in rural Florida could mean some firms would be handicapped in relation to competitors in states with superior infrastructures or who adopt hypercommunication technologies the earliest. Hypercommunications are inputs that can help firms change internally more rapidly either by speeding up the rate of internal innovation or by lowering response times to external changes. Additionally, costs for waiting, adopting early, adopting technologies too late, and adopting the wrong technology could be compounded more severely. Product life cycles are jumbled or sped up.

To Florida agribusinesses, even if technical limitations are not binding, time will tend to delay the onset of unlimited communication. Boorstin's "unlimited" communication will not instantly arise from hypercommunications convergence anymore than Gutenberg's printing press resulted in instant literacy. The hypercommunications market is springing up in phases. In the first phase, telecommunications technologies such as telephone, Internet access, voice mail, personal paging, cellular services will converge into a smaller set of separate services. Eventually, existing services and technologies will be joined by yet-to-be-conceived services and technologies to become a unified system or network. However, it is critical to note that the unified system or network (the infrastructure) and the development of new services and technologies are investment activities that must take place before convergence can occur.

Hypercommunication technologies and services may have successively fewer technical limitations as time passes so that it appears possible that communications can truly be unlimited. However, even if technical limitations are not binding, there are many economic limitations to unlimited communication. Therefore, the cyber frontier is no more "unlimited" than the western frontier was in land rush days. However, the limitations on land differ from those on communications and information because the latter two are economically weightless and cannot be used up. However, human beings have physical, attitudinal, and sociological limitations that prevent truly unlimited communications from being a reality. During Chapter 3, economic and technical foundations of the hypercommunications network will be seen as powerful sources of the growth of the information economy. It can be tempting to label them as the source of unlimited communication. However, to renew an ongoing theme, the technical properties of a technology do not automatically imply a particular economic result.

2.6 Summary

This chapter has focused on three foundations of the information economy: communication, technology, and information. Importantly, the three are interrelated in a composite way. Communication requires technology to transmit information. As that technology progresses, the volume of information communicated can rise above the ability for it to be absorbed, processed, and patterned into a more valuable form of information to be communicated later. New technologies arise at a faster rate when information can be communicated to more people at a cheaper price and more quickly. When weightless information and communication inputs and outputs are mixed with the organizational structures of modern agribusiness and new biotechnologies, the result can be difficult to analyze using conventional economics. However, a completely new economics is not required to catch up to technological changes that stem from better communication networks in order to understand the information economy. Instead, a managerial economics approach that focuses on managing innovation based on clearly defined real-world economic problems provides an economic approach that remains relevant.

With this philosophy in mind, an example may help clarify the application of non-homothetic technologies to the agribusiness information economy. An agribusiness may produce and distribute dozens of goods and services ranging from food ingredients and the transportation of vegetables to branded frozen or fresh meals. In order to coordinate these activities, an amount of corporate intelligence must be produced along with an ongoing capacity for producing it. Information processing is one input required to produce corporate intelligence, but the process requires other inputs such as communication. However, information processing and communication are also essential inputs in producing, marketing, and managing goods that are actually sold in the marketplace.

The problem is that the technological properties through which information and communication combine to create corporate intelligence do not necessarily correspond to their total economic reverberations through the firm. Information and communication are interactive, non-allocable factors. The amount of information processed and used to produce corporate intelligence cannot be distinguished from the amount used to carry out other activities of the firm. Furthermore, corporate intelligence itself is jointly produced with virtually every other output of the firm.

Hence, the inherent technical returns due to information and communication technologies may not automatically map into economic returns. Hypercommunications is a technological advancement that has important implications to Florida agribusinesses. This chapter has covered three foundations of the information economy using economic theory to discuss their general importance to all businesses. After Chapter 3 covers the economic foundations of the hypercommunication network, the question of *why* hypercommunications are needed in agribusiness should be clearer both from economic and technical perspectives.

CHAPTER 3

TECHNICAL AND ECONOMIC FOUNDATIONS OF HYPERCOMMUNICATION NETWORKS

"In network economics, more brings more." [Kelly, 1994]

Chapter 2 explained *why* hypercommunications exist economically by tracing the origins of the information economy and reviewing the new economic thinking that has resulted. Chapter 3 explains *why* hypercommunications exist technically by tracing the origins of communication networks and reviews the network economics that resulted. Chapter 2 showed that technical and economic components jointly shaped the economic foundation of hypercommunications. Similarly, Chapter 3 shows that technical and economic components jointly shape the technical foundation of hypercommunications.

The 1996 comments of Richard J. Shultz provide purpose and organization to Chapter 3, the second *why* chapter. Shultz details two stages of what he calls "engineering economics" that preceded the era of a "new economics" of telecommunications:

> The first, which could be called "classical engineering economics", was an engineer's delight. This was an era of system-wide planning of telephone networks with an overriding emphasis on systemic integrity. The little differentiation that existed was in very broad categories, such as rural-urban, residential-business, and was used primarily for pricing rather than costing and engineering purposes.
>
> The underlying premise was the concept of natural monopoly which was both an article of faith and, to continue the metaphor, was assumed to be the product of immaculate conception. This was the era of producer sovereignty, where the idea of a telecommunications market was somewhat of an oxymoron. As far as customers were concerned, they were not customers in any meaningful sense. Rather, they were "subscribers" who were not active participants but

> passive subjects who were serviced, provided for, by the telephone company which had a monopoly on what became an essential service.
>
> The second stage of "engineering economics" covers approximately the last 25 years. In this period, telephone companies were challenged by political authorities --- elected, departmental, and regulatory. But they did not question or challenge, for the most part, the fundamental precepts of classical engineering economics based on the idea of natural monopoly. Rather, they sought to supplant telco engineers as planners with social and political engineering. Such engineering was more akin to manipulation and logrolling. . . .
>
> The "new economics" of Canadian telecommunications could not be more profoundly different from "engineering economics" in either form. To invoke a current cliché, the "new economics" represents a paradigm shift, not simply adjustments at the margin. In the first place, the concept of natural monopoly has lost virtually all meaning and relevance to contemporary telecommunications. . . .
>
> Secondly the concept of a single, integrated telephone system has been "blown away", replaced by an abundance of market niches, dissolving boundaries, and a concentration on interoperability and interconnectivity.
>
> The third major characteristic of the "new economics" is the downgrading of the status of the corporate telecommunication's engineer, at least in terms of the profession's classical domination of the sector. The marketing specialist has emerged as a driving force, not only in the development of individual services, but far more importantly in shaping and determining the very nature of the telecommunications firm.
>
> All this reflects the most profound change, the collapse of both producer, and its erstwhile rival and successor, political sovereignty. . . . Once subject and serviced, the customer has been empowered and is now full citizen and in the driver's seat. For the first time, the "new economics" of telecommunications is the economics of consumer sovereignty. Telecommunications will, henceforth, be customer-driven and controlled. [Shultz, 1996, pp. 35-37]

This chapter traces the technical evolution of communication networks through both stages of classical engineering economics into the new telecommunications economics spoken of by Shultz. After a short introduction, section 3.2 defines the term digital and provides a conceptual definition of digital signals and sources. Then, section 3.3 covers technical characteristics of the PSTN. Engineering economics finds additional expression as section 3.4 covers some technical characteristics of computer networks. In section 3.5, six economic generations of computer networks are described, while section 3.6 discusses the final stage of the engineering perspective by covering how Operations Research (OR) helps the hypercommunications network gain a form. Network economics is based on these technical foundations. A literature review of the new economics of the network is given in 3.7. The chapter concludes with a short summary.

3.1 Introduction

Powerful network effects are one source of the dual myths of unlimited communications and an unlimited economic frontier. After introducing the economics of networks and considering the role played by network economics in establishing and denying the dual myths, section 3.1 will briefly consider the ongoing folklore of unlimited communications.

Network effects (often called externalities or synergies) are part of a new vocabulary of information economy terms accompanied by new economic thought. The new thought ranges from the almost unlimited "new economy" [Kelly, 1998] to the new, but limited "weightless economy" [Kwah, 1996, 1997; Coyle, 1997; Cameron, 1998] and, finally, to the limited, and well known "network economy" [Shapiro and Varian, 1998]. While there is a debate about what to call the information economy, there is general agreement that networks are playing an important role in creating a new economic model, or at least in revising the old one. Networks help speed information flow, promote innovation, and generate markets that behave differently from those in the industrial economy.

The debate about the modern economic vocabulary stems from differences of opinion concerning economic theory and network effects [DeLong, 1998, p.3]. Authors such as Kelly [1998] argue that economists are baffled by a new economic order rooted in the distinctive economic logic of networks. However, microeconomists like Shapiro and Varian claim that a new economics is not needed to understand technological change since economic laws do not change [Shapiro and Varian, 1998]. From a macroeconomic viewpoint, weightlessness or dematerialization naturally occurs as the physical economy grows into a virtual, network economy as production and consumption shift away from atoms and molecules and towards bits and bytes [Kwah, 1996].

Networks are important to the evolving U.S. economy, whether it is called new, network, or weightless. Nortel Corporation (a major manufacturer of hypercommunication hardware) reports on the enormous economic scope of networks in 1996:

> Businesses are rushing to embrace this new paradigm. Every four minutes another network is added to the world. Every 4/10 ths of a second another user comes online. Businesses spent over $725 billion on information technologies in 1996. . . . Last year they spent nearly $29 billion on network hardware according to J.P. Morgan. . . . In three years, it estimates this may rise to $72 billion. [Nortel, 1996, p.3]

If hypercommunication demand arises from characteristics of the information economy (as this "why" chapter argues), networks are responsible for many of those characteristics. The networked hypercommunications model provides users with communication possibilities that are exponentially different from the older interpersonal and mass communications models. Recent dramatic growth in business data and voice networks has introduced popular definitions of network that do not always match the meaning of the term in the economics literature.

3.2 Definitions

Before beginning a discussion of the analog-digital distinction, which is critical to defining rural hypercommunications infrastructure, the International System of Units (SI) must be introduced. These prefixes and units form the weights and measures of hypercommunications. According to the FCC in 1996, "The SI is constructed from seven base units for independent physical quantities." The SI is a part of the metric system that has been adopted by the United States and most other countries. There are seven base units, a set of prefixes of magnitude, and a number of SI derived units that are useful in hypercommunications.

Table 3-1 shows the prefixes commonly used to show magnitude. This table is important in two ways. First, technological change in computer speeds, for example, is pushing the bottom of the table (the fractional portion) further down, to ever-smaller units. In 1980, computer time units were counted in milliseconds and microseconds, but now nanoseconds and picoseconds are increasingly common. This exponential shrinkage in processing times at the table's bottom is reflected in another way at the top of the chart by exponential growth in storage, bandwidth (capacity), and speed. For example, portable storage devices have gone from floppy disks that held 360 kilobytes (kB) to 1.2 megabyte floppies, on up to 8.5 gigabyte (GB) for two-layer double-sided DVDs or 17 GB for four-layer double-sided DVDs. This is a difference of 23,611 times, or a spectacular annualized growth rate.

Table 3-1: SI common metric prefixes.

Multiplication Factor	Scientific Notation	Prefix	Symbol and Capitalization	US Name
1,000,000,000,000,000,000	10^{18}	exa	E	quintillion
1,000,000,000,000,000	10^{15}	peta	P	quadrillion
1,000,000,000,000	10^{12}	tera	T	trillion
1,000,000,000	10^{9}	giga	G	billion
1,000,000	10^{6}	mega	M	million
1,000	10^{3}	kilo	k	thousand
100	10^{2}	hecto	h	hundred
10	10^{1}	deka	da	ten
.1	10^{-1}	deci	d	tenth
.01	10^{-2}	centi	c	hundredth
.001	10^{-3}	milli	m	thousandth
.000001	10^{-6}	micro	μ	millionth
.000000001	10^{-9}	nano	n	billionth
.000000000001	10^{-12}	pico	p	trillionth
.000000000000001	10^{-15}	femto	f	quadrillionth
.000000000000000001	10^{-18}	atto	a	quintillionth

[Sources: GSA, *FED-STD-1037C*, 1996, pp. I-12, 13; *Chicago Manual of Style*, 1982, p. 393, *The Random House Encyclopedia*, p. 1449]

Two of the seven SI base units, seconds (s) and amperes (A), are central to electronic hypercommunications. They are joined by several SI derived units given in Table 3-2.

Table 3-2: Electrical and other SI derived units.

Item	Unit name	Unit symbol	Expression in other SI units
Frequency	hertz	Hz	s^{-1}
Electric capacitance	farad	F	C/V
Electric charge, quantity of electricity	coulomb	C	A•s
Electric conductance	siemens	S	A/V
Electric inductance	henry	H	Wb/A
Electric potential, potential difference, electromotive force	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Power, radiant flux	watt	W	J/s

Entries in the table are a few essential electric and electronic uses of SI units that are derived from combinations of other SI units. The most important unit in Table 3-2 is frequency.

Other than SI units, the most important units in hypercommunication are the digital units of bit (b) and byte (B). A bit is a single digit within a byte. A given byte theoretically may be of any length of bits. An older term, baud (Bd) was a measure of transmission over analog telephone lines. The baud rate measures the number of times a communication line changes per second based upon an encoding scheme for the French telegraph system developed by Baudot in 1877 [Sheldon, 1998, p.93; Bezar, 1996, p. 317]. When bits are encoded at line speed, unibit encoding is said to exist: two bits encoded per line speed is dibit encoding; three bits encoded is tribit encoding. Encoding is the changing of code as seen by user into code as transmitted over conduit such as copper wires.

3.2.1 Digitization and Digital

Bits are also known as binary digits expressed within a septet (byte with seven bits) or octet (byte with eight bits). The bit is the fundamental unit of digital communications and the source of the term digital. While a more complete explanation is found in 4.2.1 (as a preface to explaining *what* hypercommunications are), a simple definition of digital is data or information created (source domain) or transmitted (signal domain) in bits.

When the term digitization is used, it refers to converting analog information into bits in either the source domain or the signal domain. An example of the conversion of an analog source (such as a photograph) into a digital source would be the scanning of a photograph's continuously varying features into a digital file. The greater the need to precisely match the original hues and tones of the photograph, the greater the number of bits needed. Turning from the source domain to the signal domain is simple. The signal domain merely refers to whether the signal transmitted is analog (such as continuously varying sound waves) or digital (characterized by discrete pulses rather than waves).

There are several reasons digitization is important in both the source and signal domains. Often, a failure to understand the difference between analog and digital stems from confusing signal and source.

Digital sources are easily manipulated, can carry a greater volume of information in a smaller surface, at a lower per unit production cost. This is clearly seen when phonograph records are compared to CDs or DVDs. There was an evolution of analog media from primitive magnetic recording disks to Edison's single-sided phonograph technology and then into two-sided analog records. Each new analog medium was capable of storing more information. However, with the advent of digital forms such as CD and DVD, not only could more information be carried, it was more easily manipulated. An exponential growth in storage and transmission capacity, along with many media choices (optical or magnetic storage, for example) are available with digitized sources. A single DVD can carry 4.7 to 8.5 GB of data or up to fourteen times what a CD can [Sheldon, 1998, p.919]. CD's, in turn, carry many more times the information that a 33 RPM double sided stereo album. Even more important perhaps is the ability for many independent kinds of devices to use digital sources, the added simplicity of changing or reproducing bits, along with the ability of computers to process digital sources.

However, in the signal domain, digitization makes accuracy and the absence of errors in transmission more important than ever.

> Analog transmission is sufficient for most voice transmissions, because a small inaccuracy in the received signal will not be detected by a listener. But accurate transmission is absolutely essential to data transmission, where a single changed bit could completely destroy the meaning of the original signal. [Nortel, *Telephony 101*, p. 61]

The source of confusion about bandwidth (covered in more detail in 4.2) lies partly in the origin of communications in radio, television, and telephone where both the domain and signal were analog. Originally, the telephone and telegraph were the only methods of communication beyond voice, the written word, the megaphone, and the proverbial pair of tin cans joined by string. Bandwidth was a topic that interested only communications engineers who saw numerous efficiencies could be obtained by transmitting digital signals over long distances, even if conversion from and reconversion to analog form was required so analog devices could communicate. At that time, bandwidth had to do with the difference in hertz (Hz) or cycles per second between the highest and lowest audible frequencies of human speech carried by a circuit. Bandwidth was measured quality or technical characteristics and was not equated with speed.[1]

Over time, digital signal transmission developed although digitization of sources was still uncommon. Alec Reeves of ITT (International Telephone and Telegraph) developed a theory by which voice signals could be carried digitally in 1937 called PCM (Pulse Code Modulation). Development of transistors in 1947 at Bell Labs and integrated circuits at TI (Texas Instruments) and Fairchild permitted testing of PCM to begin commercially in 1956. In 1962, Bell of Ohio deployed PCM to carry traffic, and by the late 1960's, even some rural telephone co-ops began to use PCM for interoffice trunk (transport level) circuits. One reason digital transmission is important to rural subscribers is that PCM replaced analog circuits that amplified noise and distortion because analog signal noise is amplified with increasing distance. Instead of having to shout through static and crosstalk, telephone calls carried by PCM over even greater distances had substantial quality increases while carrier unit costs fell [REA, 1751H-403, 1.1-1.5].

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[1] This point is returned to in 4.2 when the generic definition of bandwidth is decomposed into elements. See also 3.4.3.

The advent of computers made it necessary for digitization within the source domain. However, the benefits of combining the computer with communications were less evident forty years ago. While it was economical to convert parts of the telephone network (within the telephone company's transport level) to digital transmission, there was no need to do so for the local loop (the wire from telephone subscribers to the telephone company). Consequently, when advances in computer technology grew faster than local loop technology, a vast amount of information from digital sources had to be converted into analog form to travel over the telephone network for data communications to occur. The reliance on digitization of source and signal is an important way the hypercommunications model differs from the interpersonal and mass models of communication. Practical issues in signal and source conversion are returned to in 4.2.

3.2.2 Conceptions of Networks

Within the economics literature, there is considerable debate about what networks represent. For this reason, four conceptions of networks give a broad overview of what networks are before presenting the details of the engineering, communication, and economic perspectives later in Chapter 3. The four conceptions are: networks as fuzzy paradigms, macro networks, micro networks, and the debate in economics concerning network externalities.

The first conception of networks (and the conception in common use) is a fuzzy concept representing almost everything a business or a person does. Used in jargon in this first way, a network may be a noun, verb, or adjective describing a business paradigm, a physical communications network, a human community, or human interaction. Therefore, one problem facing economists who study networks is how to define them because the fuzzy conception is so broad that it has no special economic significance. For example, according to the Nortel Corporation in 1996:

> Behind the buzzwords is a fundamental shift in the once isolated, and now converging, worlds of computing, networking, and communications technology. Having supported business from the back-office, computers and communications technology are now part of the fabric of a new internetworked economy. They directly affect the business' ability to operate, compete, and reach full potential. The network is more than a computer or a call center; the network is the business. [Nortel, 1996, p.3]

The second and third conceptions of network depend on whether the term is used in a more general context (though not nearly as general as in the first example), or in a more specific context such as hypercommunication network. One approach to the general versus specific in economics is described by Economides (1996) who explains the difference between macro and micro networks:

> There are two approaches and two strands of the literature in the analysis of network externalities. The first approach assumes that network externalities exist, and attempts to model their consequences. I call this the 'macro' approach. Conceptually, this approach is easier, and it has produced strong results. It was the predominant approach during the 80s. The second approach attempts to find the root cause of the network externalities. I call this the 'micro' approach. In Industrial Organization, it started with the analysis of mix-and-match models and has evolved to the analysis of price dispersion models. The 'micro' approach is harder, and in many ways more constrained, as it has to rely on the underlying microstructure. However, the 'micro' approach has a very significant benefit in defining the market structure." [Economides, 1996, p.8]

A macro network does not depend on the structure or makeup of the underlying industry, while the micro approach does. There are microeconomic and macroeconomic aspects to discussions of both micro and macro networks. With this in mind, a macro network may be defined as one of two general kinds:

> ...either a physically interconnected ubiquitous distribution system or an integrated system of switches or nodes and routes or channels with usage restrictions and enforceable interconnection agreements. The local distribution arrangement of electric, gas, and water utilities are generally thought to be the classic examples of the first definition, whereas the public-switched telecommunication network, Peter Huber's vision of a geodesic telecommunications network, and various intermodal transportation systems are examples of the second. [Lawton, 1997, p. 137]

A macro network can be a physically integrated distribution system or an integrated system of switches, nodes, and routes. A micro network can be take either of these two forms, but also depends on the market structure, network architecture, physical and logical topology, and underlying good or service the network helps to move.

Indeed, in another era, Jenny defined a system as "any complex or organic unit of functionally related units" [Jenny, 1960, p. 165] so that yesterday's system is today's macro network. A system (like a network) can be anything from a person to a political party to the entire world economy or the solar system, depending on the point-of-view of the analyst. Sub-systems form successive levels in a layer-cake of systems just as sub-networks make up levels of a network of networks (or internetwork).

Hypercommunications relies on a particular micro network or "a ubiquitous and economically efficient set of switched communications flows". [Lawton, 1997, p. 137] Crawford (1997) notes the importance of source and signal domain in networks when he states that:

> for an analysis of the incidence of transmission costs for senders and receivers of information, it is best to consider allocation of both bandwidth and rights to information. This formulation is called a market for communication. [Crawford, 1997, p. 399]

The hypercommunication network is a communication network. The economics of this network are based on two factors: form and function. First, the function of the hypercommunications network is to transport bytes of voices and data. Thus, some of the economic constraints will be rooted in technical micro network engineering and design aspects of the telephone and computer networks that are converging into a single hypercommunication network. Secondly, the hypercommunication network fosters interpersonal and mass communication across a variety of message types or forms. Thus, some of the economic constraints will be rooted in the form of the network as judged by its contents. The result is a mix between communications form and engineering function.

In common use, the word architecture might appear to describe the physical form or engineering structure of a network. In the special case of communications networks, architecture has even been used to describe the economics of communication function (message content and nature of service provided) [MacKie-Mason, Shenker, and Varian, 1996]. In network engineering, the term architecture covers the relationship among all network elements (hardware, software, protocols, etc.) while the word topology connotes a physical (or logical) arrangement. Therefore, when architecture is used, it conveys a broader meaning than topology alone to include the network's uses, size, device relationships, physical arrangement, and connections.

A fourth network-related concept is when to adopt terms such as "network externality", "network effects", and "network synergies" to model the economics of networks. One reason there has been confusion in network economics has to do with use of the term externality as a catchall word to describe all synergies and effects of networks in the economics literature.

Externalities are an important reason network economics has become a specialized field within economics. Externalities describe both external economies and external diseconomies as Samuelson points out in 1976:

> By definition, such externalities involve good and bad economic effects *upon others* resulting from one's own behavior. Since in the search for individual gain and well-being one person takes into account only private money costs and benefits as seen by him, there will then be a divergence between *social* costs and *pecuniary-private* costs. [Samuelson, 1976, p. 479, italics his]

Importantly, externalities can also refer to how the participation of others will affect us as well.

However, network economics is not merely the study of network externalities. Liebowitz and Margolis are critical of what they call the "careless use" of the term externality in the network economics literature. They prefer the broader term network effects because "Network effects should not properly be called network externalities unless the participants in the market fail to internalize these effects." [Liebowitz and Margolis, 1998, p. 1] The term synergy is also in wide use because of its interactive connotation.

Network economics examines how network effects arise in markets and the influence of those effects on supply, demand, and welfare. However, familiarity with the form and function of the hypercommunication network is a necessary foundation to the application of the economics literature to the hypercommunication problem. The discussion will return to a review of network economics in section 3.7 after more is understood about the hypercommunication network.

Finally, return to an ongoing theme about the sometimes opposite philosophies of the engineer and the economist. Engineers include relationships among the *physical* parts of any general network, (points and the lines that connect the points) when they consider a network's functional architecture.[2] The actions of *human users* on any end of a hypercommunication network may be trivially considered in engineering design, but network engineering fundamentals are composed of hardware and software, not people and communication. Furthermore, the engineering of a network depends on a changing state of technical knowledge. Therefore, the architecture of the hypercommunication network is the product of technological change combined with how various micro networks interact with human communicators who behave under economic constraints. The engineering view of a network may end with the terminal or node, but the communications and economics views consider the sender and receiver as network elements too.

Finally, conceptions of networks are rooted in concrete examples. Hypercommunication network architectures are hybrids of several working scientific conceptions. First, there are the technical characteristics of the PSTN (Public Switched Telephone Network) that came from the engineers of Bell Labs (now Lucent Technologies) and the baby Bell lab (Bellcore, now Telcordia) which are covered in section 3.3. Next, some technical characteristics of computer networks are covered in 3.4 as they were developed by computer scientists and electrical engineers. These characteristics led to the evolution of six economic generations of computer networks in 3.5, as developed by professionals from the data communications field. Finally, the multidisciplinary operations research networking literature (3.6) has combined all three kinds of networks into the technical foundation of hypercommunication networking. These four sections acquaint the reader with some elementary technical properties of the hypercommunications network. Once these properties have been established, the network economics literature can be applied to the resulting micro network of hypercommunications in section 3.7.

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[2] To an engineer, the terms architecture, design, and topology are used somewhat carelessly in this technical section. Readers should know that computer engineers differentiate among architecture, design, and topology when sketching networks. Perhaps a contextual example will help clarify meaning: specific and detailed topologies are more advanced than the generic designs presented in this section on network architecture.

3.3 Technical Characteristics of the PSTN

Work in telephone engineering pioneered communication network architecture. This discussion will cover elementary telephone network fundamentals focusing on a simplistic view of the PSTN (Public Switched Telephone Network) as it traditionally worked to provide POTS (Plain Old Telephone Service). Today's urban PSTN (which provides enhanced services far beyond traditional POTS) is more detailed than the model presented here primarily because telephone networks have adopted computer network designs and operations research algorithms. Importantly, in certain rural areas of the U.S., the POTS PSTN is still the only network. A more detailed discussion of how the PSTN works is found in 4.3.2 (telephone infrastructure) and in 4.6 (the traditional telephony market) and 4.7 (the enhanced telecommunications market).

Two main aspects of the POTS PSTN will be considered here. First, the basic engineering elements and levels are identified and defined. Second, three groups of technical problems governing the reliability, QOS (Quality of Service), and operational costs and benefits are considered.

To understand the fundamentals of the telephone network, it is first necessary to understand its place in a more general telephone connecting system. Figure 3-1 [Adapted from Beneš, 1965] shows the gross structure of the connecting system: local and remote terminals (telephones), the connecting network (a hierarchical layer of switches and transport equipment), and a control unit. As depicted here, the connecting network is a single entity, though over time it has become an efficiency hierarchy of sub-networks.

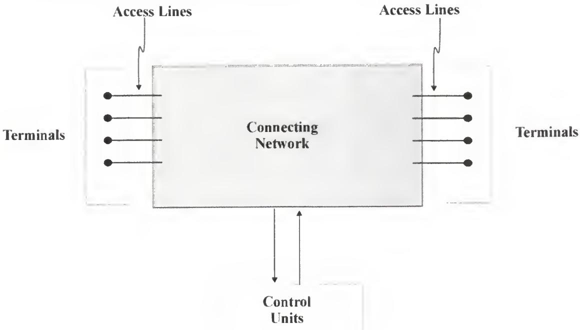

Figure 3-1: Gross structure of the telephone connecting system.

The telephone connecting system is "a physical communication system consisting of a set of terminals, control units which process requests for connection, and a connecting network through which the connections are effected" [Beneš, 1965, p. 7]. Technically, the network and the system are two different entities because two terminals (telephone stations) can be connected without a network. The control units provide the intelligence necessary to allow many telephones to be efficiently connected to what would otherwise be a dumb network.

The separation between a terminal and the network is behind the advantage of having a hierarchical network within a connecting system: dramatic efficiency. Suppose there were n terminals that needed to be connected together. Without a network, $\frac{n \cdot (n-1)}{2}$ connections would be required between the n terminals to allow a total of n x (n-1) possible calls. When the telephone system was first invented, this is exactly what was done. According to Oslin, "Early telephones were leased in pairs; there were no exchanges." [Oslin, 1992, p. 221] This historical fact introduces a fundamental property of hypercommunication networks: direct physical connection between every pair of terminals is neither necessary nor efficient for communication between all users to occur. A telephone network has the property that all n terminals can be connected for a cost dramatically below the cost of stringing $\frac{n \cdot (n-1)}{2}$ sets of wires between all pairs of telephones.

The reduction in connections is accomplished two ways, first through line consolidation and second through routing hierarchies. Line consolidation simply means the "servicing of many phones by fewer telephone lines or circuits" [Bezar, 1995, p. 46]. The number of telephones that are connected to the network (terminals) exceeds the number of connections from those terminals to the connecting network. For example, a farm may have five telephone extensions on one telephone line (access line) connected to the connecting network. The number of terminals connected to the PSTN exceeds the number of access lines because of line consolidation.

Routing hierarchies provide even greater reductions in the total number of connections. In the telephone network hierarchy, a local central office (serving a particular set of telephone exchanges) is connected to a local interexchange network or to a toll network. Rather than string a pair of wires between every pair of Florida's 8,025,917 access lines to yield 32,207,667,832,486 paired connections, the market has established over 1200 telephone exchanges (nodes) through which any single telephone subscriber may reach any other subscriber. [3] Furthermore, additional line consolidation takes place for every level of the network.

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[3] In fact, in 1998, Florida's telephone network was even more hierarchical including 3,197 different operating ILEC NXXs (telephone prefixes), 485 unique ILEC CLLIs (wire centers or central offices), 217 unique rate centers (billing exchanges), 21 EAEAs, and 11 LATAs. More detail is presented in 4.3.1 and 4.3.2.

Four chief activities take place within the PSTN hierarchy: access, signaling, transport, and switching as depicted in Figure 3-2. Assume that a call originates from the bottom of Figure 3-2 at a telephone (perhaps in Key West) to a remote telephone (in Pensacola), at the top of the figure.

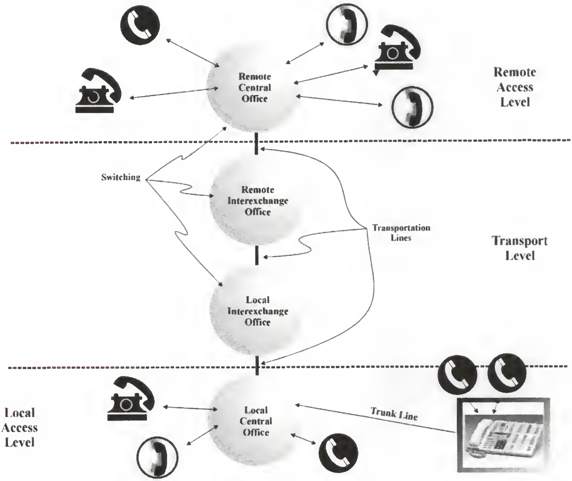

Figure 3-2: PSTN routing hierarchy.

The telephone set (or terminal) may connect locally in two ways: lineside or trunkside. Lineside telephones are directly wired via a single access line to the local central office (as on the lower left-hand side). Trunkside telephones are first connected to a PBX (Private Branch Exchange or private telephone network typically located in a business) and then connected via a trunk line (a multiple access line) to the local exchange. The first level of a call occurs at the local access level where a dialtone signal is heard and numbers are dialed. The local central office switches and transports the call to a local interexchange (perhaps in Miami). The call then travels to a remote interexchange (possibly Tallahassee). Finally, the call reaches the Pensacola exchange's central office and then a telephone connected to it. The trip the call takes from the Key West exchange to the Pensacola exchange occurs at the transport level because it passes through the multi-level connecting network. The route of the call within the local and remote access levels does not depend on the entire network. Signaling is used at the local access level to establish the call, helps route the call through the transport level, and causes the r emote telephone to ring. As telephone technology progressed, more and more calls were converted from analog to digital format over the transport level and then re-converted to analog format at the remote access level. Furthermore, many models of telephones became available (from numerous manufacturers) and the system was engineered so they could each connect into the system.

Such a network hierarchy has costs and revenues at each level of operation. At the access level, the cost of building and maintaining wires to and from each telephone in the local area served by each central office is incurred by the ILEC (Incumbent Local Exchange Carrier). Typically, a fixed monthly local access charge per access line (regardless of usage level) is assessed to cover access level costs because they tend to be highly fixed. The cost of transport lines and out-of-area switching must be covered by transport level charges. These charges have a fixed component, but vary primarily by distance and time. Finally, there is a cost to receiving calls from out-of-area which is compensated in the form of termination charges on a per call basis.

The connecting network is an "arrangement of switches and transmission links allowing a certain set of terminals to be connected together in various combinations, usually by disjoint chains" (paths) [Beneš, 1965, p. 53]. Two distinct activities are performed: nodes switch and links transport. Figure 3-3 depicts a stylized telephone connecting network. Stripped of the individual access lines, trunks, and telephones of Figure 3-2, Figure 3-3 serves a simplistic representation of the PSTN POTS network. Figure 3-3 shows only transport-level elements once the call has been received by a central office [Beneš, 1965].

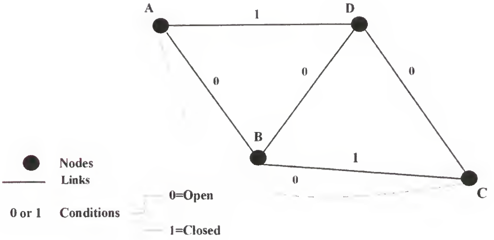

Figure 3-3: Simultaneous representation of structure and condition in a telephone network at any level of the switching-transport level hierarchy.

Points A, B, C, and D are CO nodes (switches), representing a point where a large set of terminals (telephones) access the PSTN together. AB, AC, AD, BD, and CD are generally called branches of the network. AB and BC (or AD and DC) are instead called links if for some reason a call cannot travel directly through branch AC. The numbers above each line refer to the condition (or traffic load) of the network. In Figure 3-3, zero represents an open crosspoint and one represents a closed crosspoint. Thus, at any instant, a telephone network's structure and the traffic load combine to allow a fixed number of available paths (branches and/or links) for a call to travel. The number of paths available depends on total network capacity, paths occupied by ongoing calls (combinatorial complexity), and the probability that ongoing calls will hang up (or new calls will occur) at any moment (randomness). For example, assuming no new calls other than those shown in Figure 3-3, a call from A to C could be completed directly using branch AC, or by using the path ABDC (combination of links AB, BD, and DC).

In a more general telephone network, some specialized nodes may be for transport only (used only to connect other nodes together and not connected to terminals), or may be spots where transport connections arise or are terminated (inlets or outlets). Network engineering becomes immediately more difficult as the number of inlets, outlets, specialized nodes, links and branches expands.[4] As networks grow in size, controlling units must be able to calculate all open links and branches, all free nodes, and all unbusy inlets and outlets.

The purpose of the controlling unit introduces a second point about telephone network engineering. The telephone system has three important properties: combinatorial complexity, definite geometrical (or other) structure, and randomness of many of the events that happen in the system. These properties are particularly important because a telephone call (unlike a telegraph message) requires a continuous open circuit from origin to destination for communication to occur. Therefore, underlying the network's design are mathematical algorithms regarding three kinds of representative problems: combinatorial, probabilistic, and variational. Each problem results in specific costs to each level of the network.

The combinatorial problem concerns the "packing problem" or set of possible paths a call may take given the set of available paths, nodes, inlets, and outlets. A finite number of possible paths exist to take a call through the transport level from the Key West CO to the Pensacola CO. Not all of these are necessarily the "best" path for telephone network efficiency. Additionally, each area's access level has less transport capacity than the number of access lines. For instance, Key West subscribers are limited by the number of total outgoing transport lines, and Pensacola subscribers are limited by the number of incoming transport lines. Line consolidation and routing hierarchies occur throughout the connecting system, inside and outside the connecting network.

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[4] See Skvarcius and Robinson, (1986) for a more rigorous treatment.

An important network design feature that establishes constraints for the packing problem concerns how line consolidation occurs in the network. One kind of switching network uses space division switching (where each conversation has a separate wire path) while another kind of switching network uses time division switching (where each conversation has a separate time slot on a shared wire path). Similarly, the transport networks are of two kinds. Space division switching's counterpart in transmission is FDM (Frequency Division Multiplexing) where each conversation occupies a different frequency slot. Time division switching's transmission counterpart is TDM (Time Division Multiplexing) [Hill Associates, 1998, p. 5.6]. By converting voice conversations into digital form, more conversations can be packed into a given switch using time division switching while similarly more conversations can be transported digitally using TDM.

The core probabilistic problem concerns traffic circulation (probabilities that requests for service, dialing, call completion, or hang-up will occur from terminals under instantaneously changing conditions). The most probable behavior of all users before, during, and immediately after a call has to be calculated for all possible links between nodes. Estimates of circuit availability within transport and access levels are obtained by using probability distributions of typical statistical traffic patterns given average and peak calling. Those estimates, in turn, are used as input for variational problems. Conversions from analog to digital and back again also use probability distributions and sampling to calibrate equipment for the optimal balance of quality and efficiency.

The core variational problem concerns optimal routing through the network, given the solution sets to the combinatorial and probabilistic problems. For example, a Key West to Pensacola call could possibly be routed through a variety of intermediate hops to reach International Falls, Minnesota, and then go to Tallahassee (instead of Orlando and then

Tallahassee). However, because of the distance sensitivity and fixed cost of hopping the call from one interexchange node to another, that route would not be the cheapest. Variational problem parameters could exclude some of these possible routes while leaving others available (perhaps only at peak times) to minimize transport costs while simultaneously maximizing call capacity.

Beneš contrasted the connecting network and the controlling unit of the system:

> The connecting network, in contrast to the control unit, determines which calls can be in progress, rather than how fast they can be put up. Its configuration determines what combinations of terminals can be connected simultaneously together. [Beneš, 1965, p. 15]

The network design determines the sets of combinatorial, probabilistic, and variational problems that the controlling unit will attempt to optimize with decision rules.

The network fundamentals presented so far introduce the third and final point about the traditional telephone network: economic issues. As the PSTN evolved, the economics of the network began to depend more on the historic structure and regulation of the telephone business than it did on the engineering of the network. Vogelsang and Woroch call the current setting "a complex dance of technology, regulation, and competition" [Vogelsang and Woroch, 1998, p.1]. Historically, it is argued that the telephone network architecture created inescapable economic constraints so that the telephone system was a natural monopoly.

Two interrelated issues are central to analyzing whether fundamental telephone network technology caused a particular market structure or *vice versa*. One issue is whether a system orientation or a network orientation is optimal. Another issue concerns whether telephone architecture inherently creates powerful economies of system, scope, and scale defining the traditional POTS PSTN as a natural monopoly. An important underlying concern is the impact of constantly changing technology on the equation. The issue of whether the telephone network is (or ever was) a natural monopoly is returned to in 5.4.

A few details of PSTN technical efficiency summarize this section. First, telephone networks are end-to-end open circuits. Once established, a wireline telephone call takes a dedicated circuit-switched path from caller to recipient. The call is subject to congestion only upon set up. Second, the engineering philosophy behind the traditional telephone network evolved from emphasizing a unified single system into a hierarchy of networks. Access lines that link both the calling and answering party to the network are known as the "local loop" because they connect individual users to the edge of the network at CO nodes. Third, calls are switched through nodes and transported over links that take advantage of line consolidation, digitization, routing hierarchies, and other engineering efforts to maximize call volume while minimizing costs.

3.4 Technical Characteristics of Computer Networks

A second influence on hypercommunication network design comes from work in computer network engineering and design. Computer engineers design networks based on the uses, components, scales, communications distance, network architectures (logical and physical relationships among elements), topologies (logical and physical arrangements), speed, and reliability of data networks. Not surprisingly, the broad and fast-changing field of computer networking makes a technical summary of the economic underpinnings of networking technologies an impossible task.

Nonetheless, this section will attempt that task. The specialized economics of hypercommunication networks differ in important ways from the broader field of network economics. To see this point (and to understand that some economists have misapplied macro network models to the hypercommunication case) some technical fundamentals of computer networking are needed. In this way, some idea of the economic benefits and costs (especially positive and negative externalities) of computer networks can be seen. In spite of anecdotal evidence to the contrary, computer networks are a production technology with limits and constraints. Due to the fast-changing and complicated nature of data communication, it is harder to grasp the economic ramifications of computer network technology.

Several technical characteristics of computer networks will be made in section 3.4 before the introduction of six economic generations of computer networks in section 3.5. Along with a comparison to the POTS network, four components of computer networks are outlined in 3.4.1. Common uses for data communication are considered and different technical services performed by computer networks are the topics of 3.4.2. Four technical objectives (each with important economic ramifications stemming from underlying combinatorial, probabilistic, and variational constraints) that face computer network engineers are covered in 3.4.3. Finally, in 3.4.4, the hierarchical seven-layer OSI protocol stack (representing sub-tasks of network communication sub-tasks) is sketched to unify the introductory points under one model.

3.4.1 Four Components Distinguish Computer Networks from the PSTN

Due to its complexity, the computer terminal has become a part of the network itself, in contrast to the traditional telephone. Today, individual PC's have more processing power, speed, storage, and memory than the largest computer of thirty years ago. In contrast, the telephone has not kept up with the computer's evolving complexity and it remains a simple device. However, the telephone transport network is becoming increasingly similar to an advanced computer network because it is also composed of computers. Another fundamental difference between the computer and telephone network is that while all telephones function relatively equivalently, not all computers do.[5] The many brands and models of computers are differentiated by changing technologies such as memory, processing speed, and operating system. However, with each new research breakthrough in computer technology, the task of data communication becomes more complicated because new protocols are needed to enable different kinds of computers to communicate. In addition to dramatic technological changes in the terminals at the end of a computer network, the other important difference with the POTS lies in switching. The telephone transport network has traditionally relied on physical circuit switching while computer networks rely on packet switching and virtual circuit switching.[6]

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[5] Device-device convergence has made this point an oversimplification. There are sophisticated digital business telephones capable of many specialized functions and thin client networking computers that are practically graphics displays with keyboards. See 4.1 for a discussion of all the dimensions of convergence.

Four components (hardware, software, protocols, and conduit) distinguish increasingly technologically advanced generations of computer networks from their telephone counterparts. Each distinguishing component has itself evolved into a complex structure as computers became increasingly sophisticated compared to the telephone. Hardware includes computers and peripheral equipment that collect, analyze, print, display, store, forward, and communicate data. While most hardware devices are outside the scope of this work, some hardware such as modems (4.2.2), enhanced telecommunications CPE (4.7.1), and private data network CPE (4.8.1) are covered later.

Software represents the operating systems, programs, and applications that ensure hardware will function alone and in concert with the network. A particular set of hardware and software configured to operate together is known as a platform. Protocols may be thought of as standards or rules governing hardware-software interaction. More precisely, protocols are a formal set of conventions that govern format and control of data communication interaction among differing platforms and hardware devices [GSA Federal Standard 1037C, 1996, p. P-25]. Software is typically proprietary and licensed for use by the software developing company. Protocols are typically non-proprietary but are used to constrain software development within standards governing the many tasks of data communication and computer operation. Conduit represents the transmission media that tie hardware to the network. Conduit includes guided media, known also as wireline conduit (such as wire and cable) along with unguided media, known also as wireless conduit (such as radio and microwave). The choices of conduit available to rural areas are often limited due to physical limitations in transmission distance, weather, and electromagnetic factors.

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[6] This point is revisited in 3.4.2 in greater detail.

3.4.2 Computer Network Uses and Service Primitives

Computer networks may be classified according to their uses and service primitives. Common uses include: electronic messaging (e-mail), sharing resources (CPU, printers, local conduit, and long conduit, databases, files, applications), and the transfer, reduction and analysis of information (file transfer, automated reporting and controls). Businesses use networks for collaborative BackOffice functions (manufacturing, transportation, inventory, accounting, payroll, and administration) and for customized FrontOffice uses (sales, ordering, marketing, and direct interaction with customers and stakeholders). In production agriculture, networks of remote sensing equipment may be used to monitor field conditions and even to operate irrigation equipment. Agribusinesses use computers to monitor prices, weather, livestock herd statistics, records about individual trees, and a host of other variables.

The development of the Internet has fostered uses such as real-time interaction (broadcast text, chat, voice, video) and multimedia to support online entertainment, education, and shopping. From an economic standpoint, a particular computer network may be application-blind or application-aware depending on whether the network is designed according to its use or the use designed according to the network [MacKie-Mason, Shenker, and Varian, 1996, p.2]. IBM coined the term e-business to describe a new business model that depends heavily on using the latest generations of computer networks. See 4.9.9 for further discussion of e-agribusiness and e-commerce.

From a technical or engineering standpoint, the application-aware uses are based on application-blind service primitives. The type of services (service primitives) that is available in a network is another important technical feature. The distinction among services has become especially important to recent network optimization. Primarily, the focus is on the difference between connection-oriented and connectionless services. Protocols supporting different kinds of services (techniques of communication) have evolved in the data link, network and transport layers which treat data differently as it flows through the protocol stack and in conduit. These differences are important to summarize because each can create different economic repercussions, especially with regard to pricing.

Each service type uses a different combination of protocols, stack layers, data units, and network optimization decision rules. Depending on the service type, combinatorial, probabilistic, and variational constraints in each of the four technical network objectives may tighten or relax. Furthermore, larger networks carry a blend of traffic from several service types, complicating network engineering. The service types are shown in tree form in Figure 3-4 [Jain, 1999, p. 1B-13].

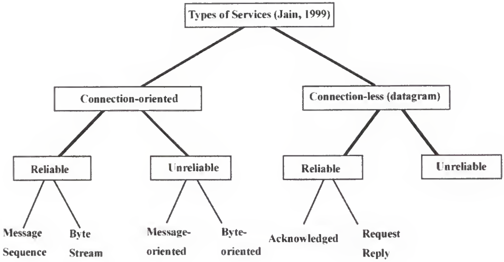

Figure 3-4: Types of services or techniques used to move data from one destination to another through a computer network.

A connection-oriented protocol sets up a logical end-to-end path (virtual circuit) to the remote host through the network before streaming data is sent. Some setup time is needed to establish the connection through the entire network. Congestion in the network can prevent the establishment of a path. Data are sent in packets (segments) that do not need to carry overhead (extra address bit information) through a virtual circuit from sender to receiver, allowing more data per packet than with a connectionless service.

Virtual circuits differ from telephone network circuits (voice pipes) because they are logical paths through packet switched networks rather than physical paths through circuit switched networks. Hence, multiple virtual circuits are able to share a single physical path. Virtual circuits can be permanent PVCs or switched SVCs. A SVC is a temporary logical path through the packet switched network while a PVC is a permanent logical path. ATM and frame relay are connection-oriented services used to connect many WANs, distributed networks, and inter-networks. The Internet's TCP protocol is a connection-oriented protocol as well. These topics are covered in more detail in 4.8 and 4.9.

Connectionless (datagram) traffic does not need to set up a path to the remote host in order to transmit bursty data. Instead, the sender creates packets that contain both the data to be sent and the address of the recipient. Hence, in relation to connection-oriented packets, connectionless packets contain "overhead" because the address data crowd out data that would otherwise have been transmitted in the same unit. The connectionless orientation frees network paths so everyone may continuously use them because each packet is considered independent of those before or after. The network sends each packet in a series of hops from one routing point (intermediate node) to another and on to the final destination based on network layer routing protocols.

Connection-oriented traffic is suited for real-time applications while connectionless is not. However, a more intelligent network is required to transmit connection-oriented traffic. Within both connection-oriented and connectionless services, reliability further distinguishes service traffic. Reliable packets are those that will be automatically retransmitted if lost. Typically, reliable connection-oriented traffic uses sequence numbers to prevent out-of-order or duplicated packets, but a byte stream method also can ensure reliability. Reliable connectionless traffic resorts to return transmission of a positive acknowledgement and lacking that retransmits missing packets.

3.4.3 Technical Network Objectives

Engineers who design computer communication networks face four dynamic and simultaneous technical objectives. The core engineering problems are to simultaneously and dynamically map each technical objective onto the four network components (hardware, software, protocol, and conduit) at the sending, intermediate, and receiving ends of computer communication. Each technical objective has the familiar set of combinatorial, variational, and probabilistic constraints introduced in the discussion of the telephone network.

The first technical objective is sending computer rate control. The sending computer tries to maximize the data rate (in bits per second) of the data it sends. The sending data rate itself is a function of the conduit's bandwidth (capacity), the conduit's signal-noise ratio, and the encoding process. Therefore, both the sending computer and the network set parameters on the sending computer's data rate using control parameters based on their own combinatorial, probabilistic, and variational constraints and on conduit capacity.

The second technical objective is signal modulation rate maximization. Conduit design and coding schemes (based on known physical laws such as the Nyquist Theorem and Shannon's Law) are used to maximize the rate at which the conduit transmits the data signal. Bits of data must be converted into pulses to travel over conduit. However, conduit[7] can carry a limited amount of data sent as a signal at a maximum modulation rate (baud rate). To transmit data as high and low voltage electric pulses that can be carried by the conduit, bits are encoded by the sending computer into a signal sent at particular number of cycles per second or baud. More precisely, the sending computer (or other hardware) converts data or text frames into bits and then into signals (electrical pulses sent at a certain number of cycles per second).

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[7] Wireline conduit types are detailed in 4.3.1.

The capacity of a particular type of conduit, its signal-noise ratio, and the distance it can carry a signal are within the domain of electrical engineering. Constraints on speed such as attenuation, capacitance, delay distortion, and noise depend on the length, shielding, and type of conduit. The physical electromagnetic limitations of the conduit have changed with new wiring (and wireless) technologies so that they are less restrictive than they once were. However, even today, this second technical objective is often the most binding constraint of the network communications problem, especially in rural areas.

The third technical objective (actually a group of objectives) is network optimization. Except in the direct point-to-point case (where a sender is linked to a receiver over one uninterrupted link), computer communication requires intermediate computers, hardware, and conduit paths and links between the two computers that are shared with other users. Network optimization is the simultaneous balance of two primary performance objectives: minimization of delay and maximization of throughput rate. This balance is achieved at an overall network and an individual connection (or message) perspective. Every network path (data pipeline) between two computers (along with intermediate hardware devices) is subject to delay and throughput constraints. On an intuitive level, Comer and Droms (1999) suggest that delay depends on the data pipeline's length, while throughput depends on the pipeline's width. Both depend on the number of intermediate nodes or hops.

Delay, the time it takes a bit to cross the network, is measured in seconds or microseconds (ms). Not counting operator delay (delay due to human behavior), delay may be of three types: propagation, switching, and queuing. Propagation and switching delays are fixed (do not depend on the level of use), while queuing delay is related to throughput. When the network is idle queuing delay is zero. However, queuing delay rises as the network load (ratio of throughput to capacity) rises.

Throughput, a system capacity constraint, often popularly synonymous with bandwidth, is measured in bits per second (bps). The physical carrying capacity of conduit establishes a ceiling rate, an overall throughput that cannot be exceeded even under the best circumstances. Effective throughput recognizes there are physical capacities to intermediate hardware devices (hubs, routers, switches, and gateways) which produce a second, lower ceiling for best case transmissions between two particular points. The effective throughput actually achieved in a particular transmission depends on the physical layout of the network, data coding (data rate) and network rate control algorithms in addition to physical link protocols and conduit capacity. [8]

Utilization may be thought of as the product of delay and throughput, or the total amount of data in transit. A high utilization is known as congestion, while a node with a high queuing delay is known as a bottleneck. Network optimization tries to lower fixed delay and increase capacity through design. Given a particular design, network optimization uses network rate control (traffic shaping) to monitor incoming traffic, while dropping or rejecting packets that exceed effective throughput. Traffic shaping's goal is use estimates of combinatorial, probabilistic, and variational properties in utilization patterns to maximize efficiency (the number of successful messages) and speed, while minimizing costs and avoiding congestion and bottlenecks. Additionally, network optimization (through simultaneous interaction of design and traffic shaping) seeks to lower utilization to avoid global congestion and local congestion in bottlenecks.

In computer network optimization, routing, packing, and the range of combinatorial, probabilistic, and variational problems similar to the telephone network are encountered. Intermediate hardware devices are used to enforce solutions to network optimization. Furthermore, computer network design protocols enable intermediate devices and computers to communicate across platforms, software, and continents. Hence, in addition to the optimizing the physical or logical topology of the network, computer network engineers are concerned with the compatible interaction of hardware and software.

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[8] Bandwidth, throughput, data rate, and associated measures are explored further in 4.2.

The fourth technical objective is flow control or the receiving computer's need to prevent the incoming pulses from overwhelming its ability to decode those pulses into bits. This can be because the sending computer's send rate exceeds the receiving computer's receive rate or because the sending application is faster than the receiving application. The receiving computer's objective is to avoid becoming overwhelmed by too fast or large a flow. In addition to such flow control activities, the receiving computer may need to acknowledge receipt or request error correction.

These four objectives are more difficult to achieve because there are many manufacturers of hardware and conduit. Additionally, software companies are typically not in the hardware or conduit business. Therefore, except in their earliest history, computer networks have not been designed as part of a uniform, centrally controlled universal system such as the original PSTN Bell system. Much original research on computer networks did come from institutions such as AT&T's Bell Labs, the U.S. Defense Department, IBM, Hewlett-Packard, and Intel where the general systems approach was emphasized. However, as networks and computing power grew, data communication evolved from a centrally planned systems approach into a sub-task approach, based on an innovative marketplace comprised of a mix of small and large vendors.

3.4.4 OSI Model of Hierarchical Networking Sub-tasks

Another important technical characteristic of computer network design is the OSI (Open Systems Interconnection) model, around which standards and protocols have been developed to foster compatible data communications among software and hardware products offered by competing vendors. To reduce the inherent complexity of studying data communication across a network, the United Nations International Standards Organization (ISO) created seven layers of data communication (each representing a distinct sub-task), known as the OSI reference model. Scientists, vendors, and users formed committees to propose and establish protocols and standards for each layer. For each layer, more than one standard exists because different networking needs could best be achieved by an "open system" rather than a closed proprietary system.

Standardization helped to prevent market failure that would have resulted from an otherwise inevitable delay as software and hardware vendors each tried to develop a single uniform way of networking. According to Comer and Droms (1999), a protocol is an agreement about communication that specifies message format, message semantics, rules for exchange, and procedures for handling problems. Without protocols (and even with them), messages can become lost, corrupted, destroyed, duplicated, or delivered out of order. Furthermore, Comer and Droms argue that protocols help the network distinguish between multiple computers on a network, multiple applications on a computer, and multiple copies of a single application on a computer. More detail about protocols is given in 4.5.2 and 4.9.6.

The OSI reference model has been criticized as a dated, theoretical model that took various standards bodies a decade to develop. Some associated standards are theoretical in that they are not yet implemented or never will be. Markets seem capable of implementing the most useful protocols, while discarding others. The seven layered OSI protocol stack is meant as a reference model of the sub-tasks involved in networked computer communications, and not as a description of reality or a definitive taxonomy.

Figure 3-5 shows the OSI model's hierarchical protocol stack. Data from local computer software applications are handed off down the layers until they are transmitted to the remote computer. At the remote end, the process is reversed sequentially so the remote user's software receives the data [Jain, 1999; Covill, 1998, Sheldon, 1998, Socolofsky and Kale, 1991].

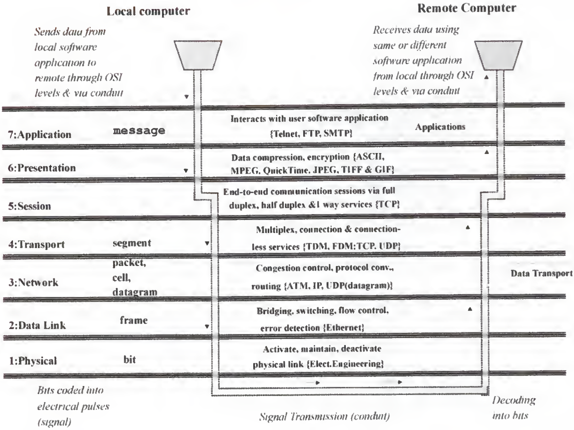
Local computer
Sends data from local software application to remote through OSI levels & via conduit
Remote Computer
Receives data using same or different software application from local through OSI levels & via conduit
7:Application
message
Interacts with user software application {Telnet, FTP, SMTP}
Applications
6:Presentation
Data compression, encryption {ASCII, MPEG, QuickTime, JPEG, TIFF & GIF}
5:Session
End-to-end communication sessions via full duplex, half duplex &1 way services {TCP}
4:Transport
segment
Multiplex, connection & connection-less services {TDM, FDM:TCP, UDP}
3:Network
packet, cell, datagram
Congestion control, protocol conv., routing {ATM, IP, UDP(datagram)}
Data Transport
2:Data Link
frame
Bridging, switching, flow control, error detection {Ethernet}
1:Physical
bit
Activate, maintain, deactivate physical link {Elect.Engineering}
Bits coded into electrical pulses (signal)
Signal Transmission (conduit)
Decoding into bits

Figure 3-5: OSI model of networking layers.

The process of data communication begins in the OSI model when a software user at a local machine sends a communication to a user (of the same or different software) at a remote[9] machine. The local software application communicates downward to the application layer (layer seven) of the protocol stack in units of data called messages. Each layer communicates with the layer directly below it, creating a new data unit to be passed on. Therefore, the message is converted, in turn, into a segment, cell, packet, or frame. At layer one, frames are turned into bits. Bits are then encoded into electrical pulses and sent as signals over conduit (bottom of Figure 3-5).

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[9] Remote and local are relative terms in Figure 3-5. The local machine could be within 100 yards of the remote or thousands of miles away.

Upon receipt at the remote end, the pulses are decoded into bits, frames, and packets as they are passed from layer one on up to layer seven. At that stage, the application layer (layer seven) sends a message to the software application used by the remote user and data communication has occurred. Importantly, the receipt of the message by the remote device is the technical engineering standard for successful data communication (machine-machine communication). The economic importance of that communication may or may not depend on whether a human operator at the remote end can process the data into useful information. In some cases, the remote computer processes and reduces the incoming data into useful information before a human operator sees it. In other cases, the efficiency and effectiveness of human-human communication is at risk if the sender causes the local application to send too much or too little data for human-human communication to occur.

At each layer in Figure 3-5, the technical sub-tasks accomplished in that layer are outlined, followed in brackets with commonly implemented protocols that operate in that layer. The transport-session layer boundary differentiates the upper layers (application layers) from the lower layers (the data transport layers) as shown on the left. On the sending end, each layer uses a different unit (envelope) to carry the original data (and the overhead it and other units add) to the next layer. On the receiving end, the overhead corresponding to each layer is sequentially stripped off to provide guidance on how that layer should handle the remaining data and overhead, until the data alone passes from the application layer to the software. In this sense, each layer in the receiving computer's stack gets the same data that was sent by the corresponding layer in the sending computer's stack.

The remaining lower layers (data link, network, and transport) help engineers with two technical objectives, to maximize the bits sent by the sending computer, while preventing the signal from swamping the receiving computer's constraints. It is noteworthy that the establishment of protocols helps to conserve engineering talent because an engineering study of each computer at every point on a network is unnecessary. Lower level (data transport) protocols accomplish flow control, error checking, and the grouping of bits into addressable envelopes (frames, packets).

The objective of overall network optimization does not map to any single OSI level. This flexibility can bring important externalities to the network. For example, without any market exchange, an advance in a data compression protocol (accomplished in layer six) can enhance overall network functionality by effectively reducing the number of bits that need to be encoded for transmission in layer one. This in turn reduces the bits, frames, and packets transported downward by layers five through two at the local machine and upwards from layers one to six at the remote machine. The protocol stack creates economic complements at one layer and they multiply through the network. This kind of interrelationship is one of the hallmarks of the more recent network generations.

Each network generation uses the OSI model differently in attempting to simultaneously achieve the four technical networking objectives. Those differences will be briefly explored during the discussion of the generations beginning next in 3.5. Very generally, the layers map onto the four network engineering objectives as follows. The physical layer directly represents the objective of maximizing the rate at which the signal travels though the conduit, the data rate. Results from electrical engineering were used to establish protocols to code bits (data) into electrical pulses (signals) to be transmitted through the conduit. Based upon the conduit's physical capacity, coding and signal technologies work with physical layer protocols to help speed up the data rate. The data rate objective is a function of bandwidth (conduit carrying capacity, the signal-noise ratio, and encoding).

3.5 Six Economic Generations of Computer Networks

Six economic generations of computer networks reduce the crazy quit of details from section 3.4 (four network components, four engineering objectives, seven OSI layers, service primitives, and the many uses of computer networks) into six eras. Each economic generation broadly summarizes the technologically evolving underpinnings of computer networking. It is important to note that the computer networks actually found in Florida agribusiness are hybrids of more than one generation, with countless inter- and intra-generational varieties. Readers who require a more technical (and engineering-oriented) treatment may consult Socolofsky and Kale (1991), Sheldon (1998), Comer and Droms (1999) or a variety of corporate sources such as Cisco (1999), Novell (1999), or Lucent-Ascend (1999).

Babbage and others are credited with early ideas that resulted in the first computer, the post WWII ENIAC. Mainframes, especially those developed at IBM, dominated the computing world until 1971, when Marcian Hoff invented the microprocessor at Intel. In 1975, the same year Sony launched the Betamax video recording standard, Bill Gates showed that the BASIC programming language could operate on a microprocessor. By 1980, Intel was able to place 30,000 transistors on a chip that ran far more rapidly than the original microprocessors did. In addition in 1980, IBM entered the PC market, hoping it would capitalize on the mainframe market share it enjoyed. IBM chose Intel and Microsoft as vendors. IBM made what many would call the worst business mistake of all time when it failed to obtain exclusive rights on Microsoft's software or Intel's hardware.

There are six inexact economic generations of computer networking: time-sharing with dumb terminals, centralized networks, early peer-to-peer LANs and later client-server LANs, client-server WANs, distributed networks, and inter-networks. Each generation represents a simplified model of a complicated technical network. Additionally, while each generation optimizes combinatorial, probabilistic, and variational problems, these classes of network optimization problems are modeled differently than in the telephone network. For example, computer networks can choose "store-and-forward" message or packet switching algorithms instead of real-time, always connected circuit-based switching algorithms of the telephone network. Data, instead of conversations are being transmitted over a computer network.[10] Therefore, technical constraints on a given sized computer network are inherently more flexible than on a similarly sized telephone network. The constraints and optimization objectives each vary according to the size and generation of computer network under discussion, its users, and the specific type of data transmitted.

A variety of network scales, architectures, topologies and communications distances traversed by computer networks are necessarily included in a single economic generation. Within each generation, a variety of software, hardware, and conduit have been implemented to loosen network constraints. The discussion will go from simplest to most complex and earliest to most recent. Two points should be noted. First, there can be considerable variation within generations due to technological innovation. Second, variation between generations can be subtler than portrayed.

Figure 3-6 makes use of a product life cycle to frame the rough historical era of each generation. Unlike animal generations, however, the gestation period is shortening at an increasing rate as a function of technological change. All six generations share three characteristics. First, each generation does not die, but becomes part of its successor. Thus, while dumb-terminal, centralized, time-share networks are ancient history (relative to computer history at least), a popular modern form of inter-network uses outsourced application servers in a thin client star network.

However, this introduces the second point, that the quality and characteristics of networking goods are not necessarily comparable through time. Today's thin client may not have disk space or run applications locally, but is capable of displaying high-level graphics that would have swamped the CRT screens and 300 baud modems of three decades ago. Third, the s-curves in

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[10] The next section covers networks that carry both voice and data.

Figure 3-6 depend on successive generations, each with new physical limits [Afuah, 1998, pp. 120-125]. New physical limits ushered in by a specific generation are often backward compatible with preceding generations.

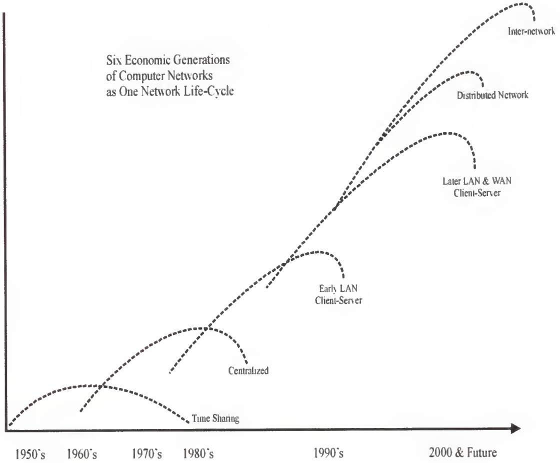


Figure 3-6: Six economic generations of computer networks plotted as life cycles in time.

3.5.1 Time-Sharing Networks and Dumb Terminals

Time-sharing networks are the first economic generation of computer network. These networks are throwbacks to the time when computers were expensive, large machines that required their own controlled atmospheres and experts. Time-sharing network hardware consisted of a single mainframe computer and a number of individual links to dumb terminals. Dumb terminals had no memory or storage capabilities so they were slower at sending and receiving data than the single mainframe they were linked to. Printing of text and graphics could be done only at the mainframe. Data flowed from a dumb terminal's keyboard over primitive conduit to the mainframe where computations were performed and print jobs were executed.

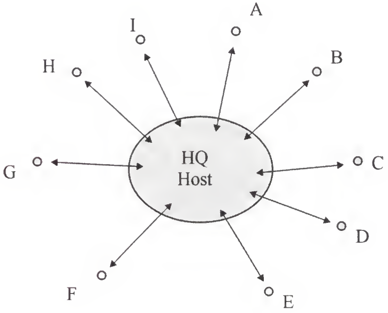
The terminal's screen could display text responses, but special keyboard control characters had to be used to prevent the display from scrolling faster than the terminal operator could read it. When receiving input from remote terminals, transmission was asynchronous so that the mainframe on the other end received characters one at a time as they were typed, serving to hamper the maximum data rate. Most data entry was in the form of punched cards that had to be taken to the mainframe to be read by special card readers. Asynchronous transmission protocols were developed to include a start bit, stop bit, and optionally, a parity bit for each character adding to the amount to be transmitted.

Computer engineers of the time concentrated on developing faster central processors and more programming flexibility instead of on improving data communication. Data communication was performed via punched cards and magnetic media instead of over physical networks. The early lack of emphasis on data communication was partly because early networks that needed long connections (outside the building where the mainframe was located) relied on noisy analog telephone local loops and analog connecting networks. Another reason was that data rates were 300 bps or slower.

Time-sharing networks were often not normally owned by the companies that used them. Instead, they were early examples of outsourcing, where access to the network, connection time, and processor time were each billable items. Current examples most similar to time-sharing networks include POS (Point-of-sale) terminals at gas stations and stores or ATMs that perform specific tasks (such as credit card verification or cash withdrawal) using extremely simple terminals that share a central processing system.

3.5.2 Centralized Networks

Centralized networks are the second economic generation of computer networks, as shown in Figure 3-7. While similar to time-sharing networks, there were several important differences. The first difference between time sharing and centralized networks was that the central computer (or minicomputer host) was typically owned by one company instead of shared. As time passed from the 1960's into the late 1970's, scaled-down mainframes (minicomputers) became more affordable for large and then medium-sized firms. Second, centralization differed from the previous time-share network in that up to 100 concurrent users could share overall computing capacity through remote batch processing and limited local processing.



A through I --- Terminals

Figure 3-7: Generic example of a centralized computer network.

The main processor (or host computer) was centrally located (at headquarters, HQ) with remote and local terminals (A through I in the figure) connected via direct links. The term centralized means that databases and the processor were kept at the host location. While later centralized networks featured remote microcomputers linked to a mainframe or minicomputer, the bulk of capacity still rested in the central host computer.

Communication volume became more synchronous (full duplex) and bi-directional (half duplex) than it had been under the simplex time-sharing regime. The centralized configuration permitted some terminal-to-terminal message traffic and local printing of jobs. Centralized computing also allowed for some limited storage and computing on some of the remote microcomputers attached to the network. Centralized computing replaced time-sharing and dumb terminals when mainframe prices fell and 8086 and 8088 PCs first became available so that an organization could own (rather than rent) its computer network. Each terminal had a limited ability to share resources of the host.

Centralized connections were accomplished locally via coaxial cable or via low-speed dial-up (dedicated or on-demand) for long connections. Conduit originally used in these systems could transmit over telephone lines at 300-1200bps to remote terminals while early coaxial cable reached local machines at a faster data rate. The original centralized networks were stand-alone networks that restricted benefits and ownership of the network to a single organization at one or more locations.

Under centralized computing, flow control and error detection were especially important because dial-up connections and local conduit were subject to interference and noise. A single interruption due to noise or interference in a large and lengthy transmission could require that the entire contents be retransmitted, often with no better results. File and application sharing began to heighten the need for data communication.

Centralized networks were never phased out of many organizations. Often, as an organization upgraded computers, a minicomputer-based centralized network remained operational as a secure, separate "legacy" network. Newer PC-based network designs relied on more user-friendly software to accomplish simpler tasks. The cost of reprogramming existing specialized centralized networks to function on less-powerful microcomputer networks was high.

Examples of centralized computers include large retailer POS cash registers, airline reservation systems, and teller and loan officer systems in banks. To enable the host to be shared among all users, message switching was used instead of circuit switching. Under early message switching schemes, the host was able to "store and forward" instructions from terminals and messages from terminal to terminal, so as to avoid congestion upon transmission (such as "busy signals") in the telephone network.

3.5.3 Early LANs: Peer-to-Peer Networks

Early LANs (Local Area Networks) are the third economic generation of computer network and would evolve into the first of two client-server generations. LANs are used to connect computers to a network within a single office, floor, building or small area. The scientific basis for LANs is the locality principle that states that computers are most likely to need to communicate with nearby computers rather than distant ones [Comer and Droms, 1999].

LANs began to be used in the early to mid 1970s to allow groups of computers to share a single connection in a larger centralized network. LANs are owned and readily managed by a single organization. They are useful to an organization seeking to share hardware, applications, data, and communications within a local area. Many LANs were peer-to-peer networks where most stations on the network had equal capacities for processing and display.

However, the sharing of a single link among multiple computers required a way to prevent two or more computers from transmitting at the same time (collision). Several arbitration mechanisms called MACs (Medium Access Controls) were developed within the OSI data link layer to avoid interruption of one computer's transmission by another's. Early LANs used ALOHA and slotted ALOHA, low efficiency protocols with collision rates of at least 26% [Jain, 1999]. The way collisions are handled differs by protocol and protocols are implemented in topologies. The IEEE and ANSI (American National Standards Institute) created standard 802.3, Ethernet[11] which recently became (and continues to be) the most popular LAN standard.

LANs are connectionless services so that once a computer gains access to the network, it puts packets on the network, but has no assurance that the distant computer gets them. LANs allow unicast, multicast, and broadcast messages so that a single transmission may be sent to a single network user, a subset of users, or all users simultaneously. LANs connect stations to the network including computer workstations, printers, and other hardware. Users could then share resources within the LAN. LAN protocols use the physical and data link layers of the OSI protocol stack.

LAN topologies define how network devices are organized logically. Figure 3-8 shows three early LAN topologies: local bus, ring, and star. All three are connectionless services. Bus topologies (which work with early Ethernet standards) use a short dedicated connection (AUI cable) to a single shared conduit. Original Ethernet wiring was thicknet, a heavy coaxial cable (10Base-5) with a maximum segment length of 500 meters as measured by the length of conduit, not by the direct distance.

Later, Ethernet cabling was thinnet, a thinner coaxial cable (10Base-2), routed directly to a BNC (T-shaped) connector on each station. Thinnet's capacity was several times that of thicknet's with a maximum segment length of around 186 meters (607 feet). 10Base-2 has very specific limitations to the total number of stations on a network. A maximum of 30 stations per segment are allowed, with trunks up to five segments long (two of which must be for distance) for a total trunk length of 910 meters (3,035 feet). Long trunks needed repeaters (devices that amplified the signal). Thinnet is cheaper than thicknet, adding to its popularity.

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[11] According to Zakon, Ethernet originated from Bob Metcalfe's 1973 Harvard Ph.D. thesis [Zakon, 1997]

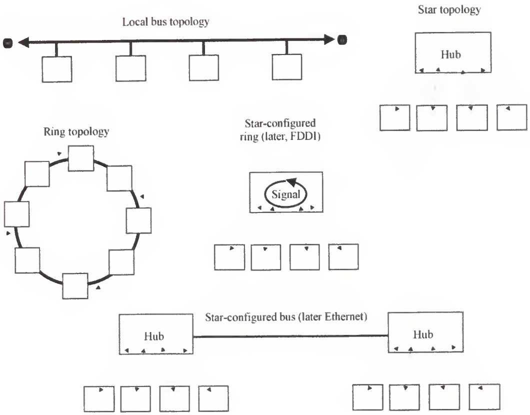

Figure 3-8: LAN topologies.

Thinnet and thicknet were expensive and the larger the network, the greater the likelihood of collisions due to delay. Repeaters helped extend maximum segment length by boosting signals, bridges helped filter traffic to avoid congestion and collision. Switches further increased throughput and design performance. However, these extra devices were expensive until the 1990's. That expense, combined with relatively high cable costs is why LANs are local.

Of the three LAN standards, Ethernet's bus topology has the advantages that fixed delay is almost zero, it is a simple protocol, and stations can be added without shutting the network off. However, it allows no traffic priorities, and (while better than ALOHA and slotted ALOHA) has a high possibility of collisions, which seriously hurts throughput at high utilization.

Under the early star topology, each computer had a separate connection to a hub or switch that receives messages from the sending computer and then sends them to the receiving computer. Hubs are physical layer devices used to connect multiple workstations, each with a dedicated cable. Ring topologies had no central component. Instead, connections go from one computer to another as point-to-point links. Bits flow in a single direction around the ring so that if there is a break in the ring, all communication ceases. Twenty years ago, the token ring protocol using the ring topology was more popular than the Ethernet bus. Unlike Ethernet, the token ring protocol allows for priority levels of traffic and handles high utilization well without collision. Stations cannot transmit until they seize a signal token that rotates around the network. Then, only the station with the token has the right to transmit thus avoiding collisions.

LANs came to be associated with client-server computing in the 1980's as early LANs became networks of more sophisticated PCs. First, the discussion will focus on the earliest LANs. Then, onto LAN topologies and the evolution of how new OSI protocols were developed to help LANs evolve further, as networked PCs ran increasingly communication intensive applications. Then, the early LAN client-server model is presented. Later generations of LAN technologies are presented along with the second generation of client-server networks, WAN-LAN client-server networks.

As the microcomputer gained prominence, many organizations began to implement the client-server model into their LANs. Client-server networks evolved from the centralized network model with servers replacing hosts and client PCs replacing less powerful terminals. However, many LANs were implemented with UNIX workstations or other minicomputer and mainframe terminals. A server computer at headquarters could be either a mainframe or a specialized server (micro or mini computer). Servers were connected (directly and indirectly) to groups of client computers (typically microcomputers) at numerous locations.

Specialized servers such as file servers, print servers, and database servers came to be used as part of LANs. File servers allowed users to share access to network files on a single, powerful machine with ample hard disk storage. Printer servers ran special spooling software to establish printer queues, removing background printing burdens from local PCs. Computer servers were used so users could share a high memory computer dedicated to performing complex computations. The use of specialized servers helped lower overall costs of hardware because most network users could have simpler PCs (or workstations) on their desktops and use high-powered machines only when needed.

3.5.4 Later Client-Server Networks: LANs and WANs

As a local network (LAN) within an organization's building, the client-server group offered a reduction in cabling requirements. Client-server networks also pioneered the shared use of individual server computers (such as F in Figure 3-9) that performed a specialized task for all users. As a wide area (WAN) or campus network, the client-server model permitted fewer "long" connections while keeping all users on the network.

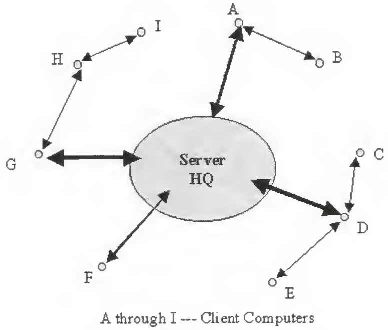

Figure 3-9: Early example of a client-server computer network.

For WANs, the client-server design allowed local transmission of messages within a group ({A, B}; {C, D, E}; {G, H, I}) without using distant connections to HQ. Network hardware and software was typically owned by the organization along with local cabling. Client-server computing took advantage of the so-called 80-20 rule (80 percent of traffic was local and only 20 percent long) to save on connection costs and take advantage of greater available bandwidth (capacity) through local connections than via long connections.

Early client-server computers were also stand-alone networks, owned entirely by a single organization to allow internal data communication. Most client-server network software allowed some local e-mail, security, and backup functions using user-friendly PC packages such as Novell NetWare instead of requiring programmers write more complicated and costly high-level program code. Client computers can share the resources of the server including the processing power of specialized servers. In the client-server model, several computers are grouped together to share transmission links and local resources.

WAN and later LAN client-server networks are the fourth economic generation of computer network. WANs have two important advantages over LANs. First, is the ability to span longer distances than LANs. Where LANs are capable of transmitting only a few thousand feet, WANs are capable of spanning thousands of miles. The second advantage is scalability. With a LAN, the addition of a new station or group of stations can be a difficult, time-consuming and even impossible task. It is typically easier to connect another LAN to an existing WAN than to add a station to an existing LAN.

Later generations of LANs saw the locality principle (where computers are assumed only to need to communicate with nearby computers) evolve into and 80/20 rule which stated that eighty percent of traffic was local, the rest distant. Later LAN wiring saw the elimination of expensive thicknet and the decline of thinnet in favor of twisted pair Ethernet. This wiring called 10BaseT, resembles a telephone line cord. 10BaseT plugs into a network card slot on each computer much like a residential telephone jack plugs into a telephone. Each 10Base-T connection goes from a single workstation to a hub or switch. 10Base-T is capable of transmitting up to 10 Mbps over the copper twisted-pair line over longer distances than thinnet. While original

Ethernet used a bus topology, later LAN Ethernet employs a star-configured bus topology (see Figure 3-8). This topology is physically a star topology, but logically a bus topology.

10Base-T specifications require the use of category 3, 4, or 5 UTP (Unshielded Twisted pair cable. Due to signal loss, the distance from station to hub cannot be over 100 meters (328 feet). Up to twelve hubs can be attached to a main hub or to coaxial or fiber backbones so that the maximum number of stations on a LAN can reach 1,024 without using bridges.

A more recent development was the introduction of Fast Ethernet. Fast Ethernet utilizes the 100Base-T specification is capable of transmitting 100Mbps over enhanced Category 5 cable (and other cable types) over still greater distances. Over fiber optic cable backbones, up to 10Mbps may be transmitted up to 4 kilometers [Sheldon, 1998]. Because the variety of less expensive cabling than fiber optic varies by type, Fast Ethernet's distance limitations tend to be less than 4 kilometers, on the order of 10Base-T. To ensure proper timing, the hub to station distance cannot exceed 100 meters with 100Base-T, while the total distance between any two points cannot exceed 250 meters using twisted-pair limitations.

New category 6 (200 MHz bandwidth) UTP wiring is becoming available in the market that should increase the capacity and distance of transmission to handle faster Ethernet networks. Category 6 (Class E) will require high performance RJ45 jacks, special training, and new standards to become a reality. Also in the pipeline is Category 7 (600 MHz bandwidth) twisted pair. However, Category 7 is a shielded twisted pair (STP) cable that cannot use existing RJ45 connectors and does not have an established standard. Category 7 STP may end up becoming surpassed by fiber optic cable to the desktop [RW Data, 1998, p. 6].

Client-server WANs can use frame relay protocol, SMDS, and ATM. All three of these connection-oriented protocols created a need for businesses to lease point-to-point or network level connections to support such higher OSI layer protocols. The private data networking market was born. It is covered in more detail in 4.8.

Connection-oriented networks are better for real-time applications or those that cannot handle packet resequencing and offer the ability to reserve bandwidth (capacity) along with hierarchical (network layer) addressing. However, connection-oriented networks use static path selection. Hence, a failure at any point along the static path can cause transmission failure. Bandwidth is often inefficiently allocated in a connection-oriented network because network resources require more capacity than they use.

3.5.5 Distributed Client-Server Networks

Distributed client-server networks are the fifth economic generation of computer network. These networks began to be seen in the early 1990's, when they were often appended to existing client-server networks. As more users and more traffic put pressure on shared resources of the client-server design, a new network design became needed to reduce congestion. By distributing both processors and databases at different locations, a single network could serve more users simultaneously.

Figure 3-10 depicts an example of a distributed network. In a typical configuration, the organization owns all client computers and owns or leases the servers. Multiple platforms are tied together using full-time connections over leased lines. Software automatically adjusts according to traffic patterns by routing traffic over the cheapest connection. All users share all resources, though typically databases and other resources are duplicated (distributed) through the system.

Distributed networks offer several advantages over client-server networks. Among those advantages are redundancy and fault tolerance. If the sole server fails (or is overloaded) in a client-server network, users may be unable to exchange data. With the distributed configuration, data that is on one server may be "mirrored" by an exact real-time copy on one or more other servers. That way, should a single server (or even two or three) fail, there is enough redundancy to achieve necessary performance. Additionally, distributed networks offer a greater number of paths for communication to occur so the network can weather problems with connections going down and traffic can be routed around congestion. Furthermore, specialized servers (such as server C in Figure 3-10) take advantage of the benefits of specialization on a larger scale than was possible with specialized client computers in the client-server model. Real-time mirrored servers can take advantage of the need for redundancy and fault tolerance for so-called "mission critical" tasks. Since global redundancy and fault tolerance throughout the network can be expensive to achieve, portions of the network can remain as they were.

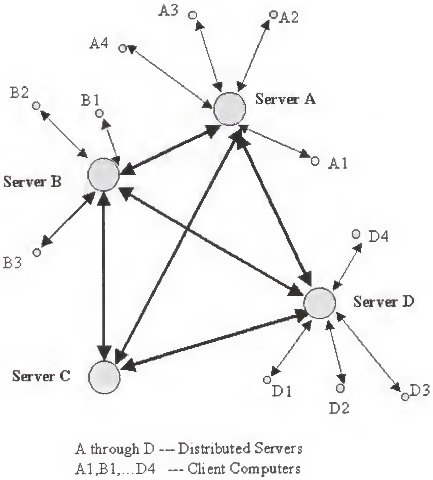
A3
A2
A4
B2
B1
Server A
A1
Server B
D4
B3
Server D
Server C
D1
D2
D3
A through D --- Distributed Servers
A1,B1,...D4 --- Client Computers

Figure 3-10: Example of a distributed network with three client-server sub-nets and one specialized server.

Users share resources in several ways. Each user in a group shares transmission lines to distant servers and hence is able to share distant server resources simultaneously. Users in a local group are able to share local resources. All users are able to share specialized servers over the WAN as well. Under the message-switching concept, network engineering allowed for transportation of unequally sized large blocks of data from point-to-point in the network. Special switching algorithms and devices called routers came on the scene that were used to regulate traffic and prevent large blocks from a single point from dominating the network to the exclusion of other users. Under message switching, routers had to buffer long blocks on disk. The conduit itself was often full duplex, capable of transmitting in both directions at once. Full-duplex circuits reduce the line turnaround time delay inherent in half-duplex lines.

Packet switching began to supplant message switching as networks became more interactive and more complicated. Packet switched networks broke up ill-defined blocks into discrete equally sized packets. The first packet can be forwarded before the second packet arrives, cutting delay and enhancing throughput. New routers were designed to buffer packets in memory rather than only on disk.

3.5.6 Inter-Networks

The sixth stylized economic generation of networks, the inter-network, (root of the term Internet) was born from the distributed network. Figure 3-11 shows an inter-network of three separate computer networks. In its most general form, an inter-network is simply a network of networks. As shown in the figure, two distributed networks (networks 1 and 3) are linked with a third centralized network (network 2). The important ideas here are scalability, compatibility, interconnection, and addressability. Until now, networks have been considered as standalone configurations providing direct benefits only to those connected. An inter-network permits the adding of previously constituted networks to existing ones so that the scale of the network is expandable. Scalability had depended on the compatibility of software and hardware among the networks to be added. However, an important part of the inter-networking configuration rests on being able to combine networks that were previously incompatible by using cross-platform protocols and gateway computers, such as (1) and (3) in the diagram, to permit communication between different systems.

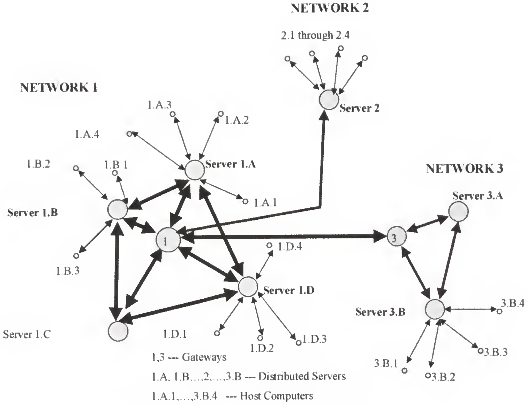

Figure 3-11: Example of an inter-network with two distributed client-server sub-nets and one centralized network.

Inter-networks can carry a mix of connection-oriented and connectionless traffic. This is especially important because both dynamic and static path selections can be made available to users. This allows connection costs to be lowered dramatically. Instead of using dedicated point-to-point connections, virtual circuits and packet switched network cut down on the number of connections to be paid for. Hence, agribusinesses with LANs at several locations (nationally or even internationally) could afford to connect them in a single WAN inter-network.

Users of inter-networks share resources of their own group, own network, and all interconnected networks. Inter-network design allowed dynamic bandwidth allocation and packet routing. A single data transmission could be split up into packets with individual packets taking different paths through the network if necessary. Figure 3-11 also illustrates an important kind of computer called a gateway which "acts as a translator between two systems that do not use the same communication protocols, data formatting structures, languages, and/or architectures" [Sheldon, 1998, p. 432]. Individual addresses such as 3.B.2 and 1.D.1 in Figure 3-11 helped in administration and security of inter-networks. However, the old 80/20 rule was now reversed. The majority of network traffic became non-local in nature, requiring greater bandwidth (capacity) and throughput.

Today particular kinds of inter-networks are often distinguished by the terms intranet, Internet, and extranet. An intranet is an inter-network that connects computers within a firm and is used for secure internal communications. The Internet is a public inter-network familiar to users of e-mail and the World Wide Web (WWW). The Internet uses the TCP/IP set of protocols. An extranet is an inter-network that connects an organization with suppliers, customers, or other stakeholders.

3.6 Operations Research and Hypercommunication Network Form

Hypercommunication network engineering is based on three sources. One hundred years of experience with telephone network design and fifty years of computer network design are the first two sources. Additionally, a macro network literature developed during the 1970s and 1980s in operations research based on algorithmic breakthroughs that came from overlaps between telephone and computer network engineering research to yield the foundation of hypercommunication networks [Hillier and Lieberman, 1990, p. 333].

This third source of engineering and architectural fundamentals for hypercommunication networks is the operations research (OR) literature. OR's multi-disciplinary scientific framework has been used to further understanding of problems from telephone networks, computer networks, and macro networks. The rich OR literature has expanded the telephone and computer network literature into a more general literature capable of designing, operating, and optimizing the interconnected mesh of data and voice networks that makes up a converging hypercommunication network. Indeed, the technical breakthroughs in this area are so vast and proceeding at such a rapid pace, that it is only possible here to discuss a few general trends.

It is noteworthy that OR's general perspective results in a positive synergy between telephone and computer network design. The more cost-efficient hypercommunication network design provides a greater volume of communication and choice of message types than would be obtained by simply combining computer and telephone networks. The hypercommunication network has resulted from new technologies that have lowered communication costs while providing dramatic increases in capacity. However, while the hypercommunication network has pushed back binding technical constraints, it has also brought forward new issues that are solved through OR algorithms.

OR models have facilitated the convergence of telephone and computer networks by providing a general networking framework. Such a generalized view is important in merging those networks (along with related networks such as wireless, paging, etc.) into the unified hypercommunication network. Much of the terminology came from graph theory in discrete mathematics [Skvarcius and Robinson, 1986]. OR also uses electrical engineering, computer science, and economics as source disciplines.

The OR orientation defines a network as being comprised of nodes (also sometimes called points or vertices) and arcs (or edges or branches). A network with n nodes could have as many as $\frac{n!}{[(n-2)!2!]} = \frac{n(n-1)}{2}$ arcs [Arsham, 1999]. If the flow through an arc from one node to another goes only in one direction, it is said to be an undirected arc, if the flow is two-way it is a directed arc, better known as a link [Hillier and Lieberman, 1990, p. 336]. There could be as many as two times as many possible directed arcs as undirected. A path is a sequence of directed arcs that connects nodes with no intermediate nodes repeated. Paths are called directed if and only if *all* arcs in a sequence are directed towards the destination node from the origination node. Undirected paths are a sequence of connecting links where the flow is from origin to destination, but all sequences of connecting arcs need not point towards the destination. A path that starts and ends with the same node is called a cycle. The entire network is connected if every pair of nodes is connected.

The OSI network hierarchy is more easily traversed by OR-inspired hypercommunication networks than by telephone and computer predecessor routing hierarchies. Recall that the telephone network and computer networks each featured combinatorial, probabilistic, and variational kinds of problems. By merging voice and data traffic into a common hypercommunications network, the dimensions of the three technical problems are changed. The resulting network is capable of greater technical efficiency. Just as the hypercommunication model resulted from the combination of the interpersonal and mass communication models, so too does the hypercommunication network result from the technical interplay of the telephone and computer networks.

As OR studied increasingly complex networks, new combinatorial algorithms were discovered that permitted network designers to understand how to pack more communication traffic onto the available paths of a complex network. Euler's answer to the Koenigsburg bridge problem was an early example of how to approach the traversibility of a network to find a single route that would connect each node while crossing each arc exactly once [Miller and Heeren, 1978, p. 327-328]. Such traversibility problems were a special case of combinatorial problems in network design that allow efficient message distribution from a single sender to mass recipients.

The advent of computers allowed computers to produce reducible configurations of complex arrangements that could not be otherwise categorized as in the case of the Appel-Haken four color map theorem [Appel and Haken, 1977]. In that case, only with a computer were mathematicians able to prove an 1879 theory that any possible map of bounded areas required a maximum of four colors. Graph theoretical rules were used to enumerate the total number of possible map configurations to 1,936 from over ten billion logical calculations. Statistical and mathematical work in OR was used to program computers in a similar way to reduce network design combinatorial problems (such as the packing problem) into the simplest form.

OR is useful with new generations of probabilistic problems of network design and optimization that came from larger, more sophisticated voice and data networks. Traffic over computer networks that previously could not have been managed due to the large numbers of nodes, links, paths, cycles, and message types could now be modeled and estimated using computer analysis of known multivariate probability distributions.

More specifically, Table 3-3 summarizes how OR has been used to combine the three classes of problems in telephone transport networks with the four computer network engineering design objectives into a set of technical algorithms for a converged hypercommunications network. In reality, many of the algorithms listed cannot be compartmentalized as neatly as shown in the table. The purpose of the table is only to show the range of OR algorithms and how they fit together. No attempt will be made to explain individual algorithms here since far better treatments can be found elsewhere [Corman, Leiserson, and Rivest, 1994; Lawrence and Pasternack, 1998; Arsham, 1999].

Combinatorial class problems involve the geometric structure and topology of a network originated in telephony from finding the full set of possible paths a telephone call could take over the transport network. The packing problem becomes exponentially more complicated for packet-switched and cell-switched networks where individual calls or data transmissions are split into parts. Further adding to complexity, separate calls or data transmissions share physical connections via statistical multiplexing (where a single physical link is shared in space or time with other users). Multiplexing comes up again in 4.2 when QOS and transmission are covered.

Table 3-3: OR algorithms and convergence of telephone and computer network optimization.

Three problem classes of telephone networks (columns)	Combinatorial (packing)	Probabilistic (traffic circulation)	Variational (routing)
Four computer networking design objectives(rows)			
1. Sending rate control (each node)	Interior point algorithms	Burstiness models	
2. Receiving flow control (each node)			
3. Signal modulation rate optimization (each arc)	Non-statistical multiplexing algorithms		
4. Network optimization (all arcs & nodes)			
a. minimize average delay of entire network	Multi-path routing	Queuing theory	
b. minimize largest delay in any network segment	Multi-path routing	Distance-vector (Bellman-Ford algorithm)	Link-state, Floyd-Warshall (shortest path algorithms)
c. maximize traffic over capacity	Non-statistical multiplexing algorithms.	Arc capacity perturbation analysis	Tolerance analysis
d. minimize NTS (non-Traffic Sensitive) costs	Drop algorithm	Statistical multiplexing & Time-to-arrive	Minimum cost net flow models
e. minimize TS (Traffic Sensitive) costs	Greedy drop algorithm	Statistical cost perturbation analysis	Activity-duration

Sources: Corman, Leiserson, and Rivest, 1994; Lawrence and Pasternack, 1998; Arsham, 1999.

The probabilistic problem of traffic circulation is similarly made more difficult when computer networks are combined with voice networks. Burstiness models are used to take the ratio of peak to average traffic between points so that sending, transmission, and receiving rates will be adjusted appropriately for the message primitive and traffic type. Many kinds of statistical and probabilistic algorithms are used to minimize TS (Traffic Sensitive) and NTS (Non Traffic Sensitive) costs, decrease delay, and maximize traffic efficiency over partial and entire networks.

The variational class of problems focus on how switching structure and message type interact dynamically. While each of the three classes is important, the variational class is particularly important in a variety of network optimization tasks such as queuing delay, propagation delay, throughput, and congestion avoidance in the converged hypercommunications network. Variational classes of problems usually involve algorithms with nested combinatorial and probabilistic algorithms.

Table 3-4 summarizes the main technical characteristics of the networks covered in Chapter 3.

Table 3-4: Comparison of technical network characteristics.

Network	Hardware	Levels	Conduit	Function
Telephone connecting system	Individual phones, switches	≤ 5	Copper & Fiber	Analog telephone calls (4 kHz)
Telephone Transport	CO equipment	≤ 4	Fiber	Digital telephone transmission (56-64 kbps channels)
Time-share network	Mainframe, dumb terminals (leased)	2	Copper	Share cost of computing among many firms.
Centralized computer	Mainframe, dumb terminals (owned)	2	Copper	Data rate to 14.4 kbps
Client-server LAN	Server & PCs or workstations	2	Short-range coax, STP, or wireless	Local data communication & peripheral sharing
Peer-to-peer LAN	PCs (Tick clients)	1	Short-range coax, STP or wireless.	Local data communication, peripheral sharing, collaboration.
Client-server WAN	Server and PCs or workstations	≥ 2	Leased lines or dedicated connection	Data communication over distances, collaboration.
Distributed network	Servers, PCs, workstations, some multiple platforms, thin clients	≥ 3	Leased lines or dedicated connection	Local & distant data communication, peripheral sharing, collaboration.
Inter-network	Multiple platforms: servers, workstations, PCs, thin clients & devices	n	All, virtual circuits	All

The technical network characteristics shown in Table 3-4 play a further role in 4.8 where they are used to separate private data networking and the Internet from the PSTN and enhanced telecommunications. As will be seen then, the advanced features of the most recent generations make hypercommunications possible.

3.7 Network Economics

There are many sides to the network economics literature. Many of these have already been discussed in Chapter 2 and earlier in Chapter 3 including weightless economics, new economics, and the path dependence school. Also on the list are Internet economics (McKnight and Bailey, 1997), new evolutionary school views of dynamic market externalities (Keibach and Posch, 1998), and a new view of market structure in the network age (Varian, 1999).

Yet, while the network economics area is a broad and exciting area, researchers have produced an incredible variety of literature, much within the past five years. For example, one online bibliography on network economics is over sixty-six single-spaced pages.[12] [http://www.stern.nyu.edu/networks/biblio.html downloaded 9/2/99]. Nowhere in economics is the issue of time compression so important as in the network economics field. While possible future "seminal papers" wait for academic review and journal publication, they often are already being tapped by academia, industry, and government.

The hypercommunications network (especially the Internet) has produced new forms of academic communication that are faster, cheaper, more interactive, and have greater freedom of entry and fewer gatekeepers than the standard technical or economic journal. Varian argues that now the "unit of scholarly communication is the thread. The thread allows interaction, shortness with detail behind it, etc. " [Varian, 1996, p. 51] However, the thread is not without problems.

Unlike traditional academic literature, the new Internet "literature" demands careful scrutiny for several reasons. Citations can be troublesome. In every case a URL (Uniform Resource Locator, or web address) can be used, together with date, time, file type (such as HTML), and title. However, new versions can appear overnight and pagination (unless an Adobe PDF or other standard is used) varies by monitor, printer, web browser, and version.

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[12] By June 2000, there were seventy-one pages on the site.

Most departments and many faculty members offer online working papers with numerous public depositories such as the Washington University economics working paper web site, http://econwpa.wustl.edu/wpawelcome.html. However, because of interactive websites, web address changes, hosting equipment and software changes, and due to QOS (Quality of Service) issues, today's web citation is tomorrow's "404 file not found".

Another reason for scrutinizing Internet literature and scholarly communication threads is source credibility. Because the cost of participation is lower, access is anonymous, and much of the posted information is probably not read, no imprimatur of quality or academic approval has been stamped on the online network economics literature.

With an introductory warning out of the way, a bare introduction to network economics can be developed. In 3.7.1, several economic fundamentals about networks are given. Next, the topic of positive network synergies or effects (also called externalities) is considered in 3.7.2. Negative network synergies and effects are the subject of 3.7.3. Sources of externalities are explored in 3.7.4. Finally, sub-section 3.7.5 will examine the implications of network economics for firms such as agribusinesses.

3.7.1 Economic Fundamentals of Generic or Macro Networks

The network literature typically distinguishes between the properties of specific (micro) networks from the properties common to all networks (generic or macro networks). Generic networks include a variety of structures from oil distribution, electricity, and commodity flow networks to hypercommunication networks. Table 3-5 summarizes six sets of properties to yield eighteen economic fundamentals shared by all networks.

Table 3-5: Economic properties of generic and hypercommunication networks.

Author and property	Generic network economic implication	Hypercommunications network implication
Fundamental technological characteristics, David (1992)		
Capacity indivisibilities	Increasing returns (decreasing costs)	Deregulation (Ch. 5), falling prices (6.4)
Benefits to single users depend on accessibility of other users	Demand externalities	High per subscriber valuations fall with time (6.3), Incentives for early subscribers (6.4), Installed base
Compatibility	Supply externalities	Path dependencies (3.2.2, 3.7.3), standards battles (4.5.2).
Factors common to all networks, Crawford (1997)		
Capacity to produce cannot be stored	Network must be designed for peak load.	Dedicated vs. shared circuits (4.3, 4.7.3), packet or cell switched vs. circuit switched (4.7.4, 4.8.2, 4.8.3), Line consolidation (3.3).
Net flow vs. total flow	Node to node transfers can be perfect substitutes or perfect complements.	Bandwidth arbitrage argument.
Frictional or line loss	Not everything sent from one node to another is received.	In-band vs. out-of-band signaling. T-1 vs. ISDN-PRI (4.3.2, 4.7.3, 4.7.4), attenuation (4.3.2, 4.4.1)
Self-powering	Costs reduced, possible self-sufficiency	DC-powered devices (certain telephones) work in power failures.
Multiple units & capacity measures	Confusion in pricing	Confusion in pricing: TS, NTS, QOS, and bandwidth (4.2).
Economic ownership, Liebowitz and Margolis (1994)		
Ownable	Costly to configure, has physical parts	Physical infrastructure (4.3.2, 4.3.3, 4.4, 5.2.2).
Metaphorical or virtual	Inexpensive to reconfigure, few physical parts	Virtual circuits (3.4.2, 4.8.2), architecture (3.2.2).
Transparency, MacKie-Mason, Shenker, and Varian (1996)		
End-to-end non-transparency	Service provider provides link among nodes, not aware of what user receives.	Application-blind telephony, data network carriers, ISPs (4.6-4.9).
End-to-end transparency	Service provider knows the content or quality of flows among nodes.	Application-aware, value added services (4.9.3-4.9.10).
Network developmental stage, Noam (1992)		
Cost-sharing	Private	Private data networking (4.8)
Redistributory	Mixed, regulated	Traditional telephony (4.6)
Pluralistic	Mixed, un-regulated	Internet (4.9)
Layered hierarchical structuring, Gong and Srinagesh (1997)		
Intellectual (high level)	Intelligent networks.	Content & value-added networks.
Physical (lower levels)	Unbundled bearer service, common carriage.	Access level, wireline (4.3), wireless (4.4) transmission
Network layers	Virtual network hierarchies.	Virtual layers, OSI except physical level (3.4.4)

The third column of Table 3-5 points out several implications specific to hypercommunication networks and points to locations in the text where these are discussed.

The first of the six sets of economic fundamentals are from David (1992), who mentions three fundamental technological characteristics of "generic" networks from the economics literature. The first of these is that production and distribution facilities have significant capacity indivisibilities so that "over some range of operation there are increasing returns (decreasing costs)." [David, 1992, p. 103] Second, benefits available to single users depend upon how accessible other users are, "implying the existence of externalities on the demand side of the market" [David, 1992, p. 103]. Third, there are issues such as interconnection and standards resulting from technical characteristics of networks. In this way, according to David, economics reacts to technical developments (rather than the reverse):

> Technical (and hence the economic) performance of the network involves interconnectedness, which, in turn, requires that some minimal level of compatibility (and inter-operability) be assured among the system's components either by ...standards", or "gateways connecting otherwise isolated systems. [David, 1992, p. 104]

The next set of economic fundamentals of generic networks includes five economic properties mentioned by Crawford (1997). One property of networks is that "their capacity to produce cannot be stored, so capacity unused today cannot be saved for use tomorrow. Note that the storage of a network's capacity to transmit is distinct from the storage of objects transported over the network." [Crawford, 1997, p.393] Since "the good transmitted on the network itself may be storable" or have a store-and-forward capability there are several implications for hypercommunication networks. These include the requirement to design hypercommunication networks for peak capacities and the rationale for shared versus dedicated circuits. Other technologies such as packet switching and multiplexing serve to limit peak loads, often with insignificant unit adoption costs.

Crawford's second generic network property is that there can be important differences between net and total flows. In "commodity" networks, one unit transferred from node to node is a perfect substitute. However, in communications, "receiving mail (unless there is cash in the envelope) or phone calls intended for another party is typically useless for both the sender and the recipient." [Crawford, 1997, p. 393] Yet, in the case of broadcasting, watching the President speak on one channel as opposed to another is almost a perfect substitute. This property is important in the pricing of converged networks where bandwidth arbitrage could exist. However, while digitization does make one bit seem to be the perfect substitute of another, the message primitive, sender, receiver, and time urgency prevents bit or bandwidth arbitrage from being a global condition given today's technology.

Crawford's third property is frictional or "line" loss. In data networks, "We may think of the bandwidth used to carry header data as a frictional loss…" [Crawford, 1997, p. 396] Indeed, noise in general can be thought of as a frictional loss due to conduit properties. As sections 4.3 and 4.4 will show, line loss in the form of attenuation is a common barrier to wireline and wireless voice and data communication. Attenuation is more of a problem with digital communication because of the sensitivity to error involved. Attenuation prevents both wireline and wireless signals from traveling longer than certain ranges so that this is particularly important in rural hypercommunication networks.

Crawford's fourth property is whether the network is self-powering. "If the material used to overcome frictional losses is the same as the matter transported on the network, the network is self-powering." [Crawford, 1997, p. 396] While hypercommunication networks are not normally self-powered, there are important QOS (4.2.4) exceptions. For example, most modern business telephone systems do not work if the business loses power, though DC-powered telephones receive DC power through the line and can continue to function.

Crawford's last property (multiple capacity measures) is especially important to hypercommunications. In hypercommunications, pricing methods abound because there are multiple units of measure (bits, minutes, distance) and multiple capacity-related measures (storage, bandwidth, throughput, data rate). Section 4.2 covers bandwidth and QOS to demonstrate the complexities involved.

The next set of economic properties of networks concerns economic ownership. A network may be either ownable or metaphorical [Liebowitz and Margolis, 1994]. An ownable network is costly to configure partly because it has many physical parts. Ownable networks (such as the PSTN and CATV networks) can easily exclude non-paying customers through disconnection. Because of the physical parts, there are substantial capital investments and well-defined property rights. Metaphorical networks such as all English speakers or Chevrolet owners are based on direct interaction, but not physical connections. Ownership is difficult, because it is hard to exclude non-paying customers.

Virtual networks lie between ownable and metaphorical networks. They are like ownable networks in that exclusion is possible, but because there is often no real physical component, pricing is below the analog service offered in a true ownable network. If a business has a single Internet e-mail account, it may establish numerous virtual e-mail addresses. Similarly, with a single telephone line, many DID numbers (virtual telephone numbers) may be established. Calls and e-mails to the virtual numbers or addresses are routed to the physical connection at a miniscule cost compared with adding physical connections for each number or address. When a business hosts its own domain or has its own PBX telephone system, the cost of adding an additional extension or address is negligible. The virtual network gives the appearance of a physical network, but for a low cost. Virtual circuits are one example of how businesses use virtual network relationships to slash their bills compared with a d edicated, fully-owned network.

MacKie-Mason, Shenker, and Varian (1996) point out another property of networks, transparency. The transparency of a network has to do with whether the firm that provides network access is aware of what individual users receive from being connected to the network. In some architectural configurations, the service provider simply acts as the link between network nodes without having any control over what the network transmits. In other cases, the service provider knows (generally or precisely) the content or quality of the transmitted matter.

A communication network can be application-blind as is the case with the Internet or other "common carrier" networks, or application-aware as with cable TV or online service networks [MacKie-Mason, Shenker, and Varian, 1996, p.2]. Among application-aware networks, (especially in the area of information networks, but not exclusively so), some networks are content-aware or content-blind.

Another set of economic network characteristics is given by Eli Noam. Noam names three stages of telecommunications network development. Noam's three stages include cost-sharing networks, redistributory networks, and pluralistic networks. Cost-sharing networks have users sharing equally (according to access and/or use) in the price of the full cost of the private network. Private data networks (used by firms for WANs) are examples of cost-sharing networks.

Redistributory networks have certain users paying parts of other users' costs. This occurs in heavily regulated public networks such as the PSTN where urban users subsidize rural users and businesses subsidize residential service. Redistributory networks also occur when one group of users wants network access so much that it is willing to subsidize other users' access. New users impose a burden on network resources. However, power users may know that prices will fall and their benefits will rise by adding the subsidized user group. This is the principle behind the federal e-rate universal access charge assessed by telcos for telephone service. Pluralistic networks have a mixture of public and private carriage, with the Internet cited as an example. However, "the very success of network expansion bears the seed of its own demise", creating a "tragedy of the common network" [Noam, 1992, p. 124].

The last set of properties is related to network layers and levels. Intellectual or high-level networks are typically intelligent networks that provide customizable service to users. In hypercommunications this often means content such as subscription websites, video on demand, and customized information. Low-level networks are common carrier or physical level links that are used to gain access to higher network levels. Network layers such as the OSI model are often virtual structures that allow higher layers to sit atop lower layers. The net result of layers and levels is "...a recursive relationship in which the cost structure of services provided in any layer is determined by prices charged by providers one layer below" [Gong and Srinagesh, 1997, p. 68].

As particular network externalities are discussed, several points need to be remembered. First, network effects are counted in economics in two ways: as social costs and benefits or as pecuniary costs and benefits. Second, discrete choices (the inframarginal case) and continuous choices (the more familiar marginal case) are two different ways of analyzing network effects. Finally, network effects can be in occur in production (supply), in consumption (demand), or in both.

3.7.2 Positive Network Effects

The economic properties of networks combine to create much of what is called new economics. An important ingredient is the network externality, or more properly, according to Liebowitz and Margolis the "network effect". Liebowitz and Margolis reserve the term network externality

> . . . for a specific kind of network effect in which the equilibrium exhibits unexploited gains from trade regarding network participation. The advantage of this definition over other possible definitions is that it corresponds with the common understanding of externality as an instance of market failure. [Liebowitz and Margolis, 1994, p. 2]

Whether known as network effects or network externalities, this phenomenon is said to make supply curves slope down (in the case of network production externalities) and to cause the demand curve to slope up.

> Thus, in the case of the paradigmatic network industry the market demand schedule slopes *upwards* (due to demand externalities) and the market supply schedule slopes *downwards* (due to indivisibilities and supply externalities), with the consequence that their point of intersection defines a 'critical mass' or

> 'threshold' scale for the activity's economic viability, rather than a stable equilibrium level of production..." [David, 1992, p. 104]

However, it turns out that such externalities (if positive) do not invalidate the supply and demand curves of conventional economics. Instead, production and consumption externalities are easily analyzed within the conventional framework.

> Networks exhibit positive consumption and production externalities. A positive consumption externality (or network externality) signifies the fact that the value of a unit of the good increases with the number of units sold. To economists, this fact seems quite counterintuitive, since they all know that, except for potatoes in Irish famines, market demand slopes downwards. Thus, the earlier statement, 'the value of a unit of a good increases with the number of units sold,' should be interpreted as 'the value of a unit of the good increases with the *expected* number of units to be sold.' Thus, the demand slopes downward but shifts upward with increases in the number of units expected to be sold. [Economides, 1996, p. 675]

Thus, the analysis of network effects depends critically upon expectations of producers and consumers. However, the unit of analysis can be hard to identify when network effects are considered, as Gong and Srinagesh mention.

> Call externalities arise because every communication involves at least two parties, the originator(s), and the receiver(s). Benefits (possibly negative) are obtained by all participants in a call, but usually only one of the participants is billed for the call. A decision by one person to call another can generate an uncompensated benefit for the called party, creating a call externality. Network externalities arise because the private benefit to any one individual of joining a network, as measured by the value he places on communicating with others, is less than the social benefits of his joining the network, which would include the benefits to all other subscribers. Again, the subscription decision creates benefits that are not compensated through the market mechanism. [Gong and Srinagesh, 1997, p. 65]

The impact of positive externalities can be seen when considering that an agribusiness with an Internet account may save time by B2B cyber shopping, finding new customers, recruiting new employees, and experiencing many other benefits. Those benefits due to joining the network (network effects) may dramatically exceed all economic costs associated with becoming an Internet business and are further heightened as new customers and suppliers join the network. However, there may not be evidence of market failure, so such network effects are not properly called externalities.

There is plenty of evidence supporting the existence of positive externalities in hypercommunications. For example, consumption externalities abound in the telecommunications literature [Squire, 1973; Rohlfs, 1974; Artle and Averous, 1975; Littlechild, 1975; Oren and Smith, 1981]. Generally, positive network effects of joining a communications network depend on the net social or monetary benefit (or the net present value of the stream over time) that exceeds the full economic costs of joining. However, network effects can also be negative, either individually, or as a net effect.

3.7.3 Negative Network Effects

As Liebowitz and Margolis state, there is no

> . . . reason that a network externality should necessarily be limited to positive effects, although positive effects have been the main focus of the literature. If, for example, a telephone or computer network becomes overloaded, the effect on an individual subscriber will be negative. [Liebowitz and Margolis, 1994, p. 1]

In fact, many kinds of negative network effects are possible. Chief among these in hypercommunications is congestion. There are also call externalities, social-managerial effects, and the danger that a single defect can destroy or damage one or multiple connections.

Congestion can include connection establishment delay and connection establishment failure for connection-oriented services such as dial-up Internet access. Congestion can cause negative network effects in other ways such as noise on wireless telephone calls, slow-loading web pages, e-commerce sites that cannot handle order loads, etc.

Negative call externalities (negative call effects) result when being on a network creates undesired costs related to individual calls or messages. Telephones connected to the PSTN face the chance of receiving prank calls, undesired sales calls, or conversations that interrupt work or pleasure. E-mail subscribers get negative externalities when they receive spam or such a large volume of relatively unimportant messages that time is lost wading through mailboxes or important messages are missed altogether.

Social-managerial effects were covered (along with other negative externalities) in the discussion in 2.5 about "unlimited" communication. Essentially, these effects include economic costs that result from retraining workers, failing to predict which technology a firm should invest in, and other path dependency issues. For rural areas, there has been a great deal of discussion regarding worsening of the gap between information have's and have not's as technology advances. In spite of the promises of communications networks, a digital divide has been established between those who have the infrastructure and training to access them and those who do not. Some research suggests this "digital divide" is widening rapidly [NTIA, 1999, p. xiii].

The dangers of belonging to a network have already been discussed under security topics in 4.2.4 and 4.9.8. Negative hypercommunication network effects that can result include such things as cyber crime, viruses, crackers, identity theft, eavesdropping, and other threats to the wealth or well being of businesses and individuals. Many costs of remedying these problems by purchasing security equipment and software, hiring experts, and other protective measures are direct, but also involved are non accounting costs of security. All these are deducted from positive network effects.

Finally, there is an opportunity loss due to non-customization:

> ... Information services are presently being offered as broadcast media, a misuse of their potential comparative advantage as shared network systems. The advantage of shared network systems is best utilized through developing services that are user-specific. [Steinmueller, 1992,p. 192]

If information that is obtained over hypercommunication networks tends to avoid using those networks to achieve maximum positive benefit, then there has been a welfare loss. The argument here does not concern benefits that are lost, but benefits that would have been greater to users if certain actions had been taken in content writing, design, and programming. Specifically, this is a direct reference to using the mass communication model instead of the hypercommunication model (see 2.2.2. and 2.2.3).

3.7.4 Direct and Indirect Sources of Network Externalities

Indirect network effects refer to the degree to which a technology's value depends on the set of complementary goods it has. Many argue that DVDs or CDs are examples. Indirect externalities are often classified pecuniary or technological. Pecuniary externalities are ones where "one individual's or firm's actions affect another only through effects on prices" while with technological externalities "the action of one individual or firm directly affects the utility or profit of another" [Greenwald and Stiglitz, 1986, p. 229].

Direct network effects are inframarginal, internalized through ownership, or internalized through transactions. Direct effects refer to the degree that a technology's value is based on its ability for users to interact with other users of the network. Importantly, as Liebowitz and Margolis (1994) point out:

> The literature of conventional externality is largely concerned about the level of externality-bearing activities --- too much pollution or congestion, too few Good Samaritans. The network-externality literature, on the other hand, is rarely concerned with determining optimal network size, but often concerned with the choice among possible networks, i.e. discrete choices. [Liebowitz and Margolis, 1994, p. 8]

However, the "representative network externality problem" consists of cases where solutions require individual and group actions and dependencies.

> ...Some action would be socially wealth-increasing if enough people joined in, but each agent finds independent action is unattractive. The familiar tax-and-subsidy solution to externality problems (a solution based on altering marginal magnitudes), although suited to changing the scale of externality-generating activities, is not in general appropriate for discrete choices (inframarginal problems). Instead, the network effects diagnosed in this literature pose problems of transition, a problem of coordinating movement from one equilibrium to another. [Liebowitz and Margolis, 1994, p. 8]

However, the importance of discrete and group choices may be overstated in some analyses, especially in the context of the hypercommunications policy environment in Chapter 5 where the conventional marginal-orientation remains important.

Often overlooked is the distinction between inframarginal and marginal analyses of network effects that is especially important with lumpy path dependency problems. In such cases, solutions may differ depending on how the problem is phrased. In the most easily solved case, the objective is to find the optimum equilibrium *given* that a particular path has been chosen. In a frequently encountered case, the objective is to find the optimal path. A commonly used example is whether the QWERTY typewriter keyboard was in fact the most efficient way to arrange the keys. At this stage, even if QWERTY was found to be far less efficient than other keyboard configurations, it is chosen simply because of its gigantic installed base. There are simply so many keyboards and typists trained in the QWERTY method that adjustment costs swamp benefits of switching methods. Path dependencies include OS such as Windows, applications such as the MS Internet Explorer Browser, and DCE and DTE. Potentially, poor software or hardware development paths are the largest negative network effects.

3.7.5 Implications for Agribusiness from Network Economics

There are several implications from the network economics literature for agribusiness. The first concerns equity and competitiveness. Specifically, small firms could be disadvantaged as Macdonald mentions:

> Denied access to the major information networks in their industries, small firms are forced to incur the expense and confusion of tapping into a profusion of specialist networks, to be content with the service provided by the public network, or to continue to rely on older forms of information transfer. None of these courses is likely to give them greater competitive advantage. [Macdonald, 1992, p. 65]

Larger agribusinesses may be in a better position to benefit from a networked economy than their smaller competitors. For certain industries where numerous smaller firms predominate (such as production agriculture), the networked economy could have profound implications on structure because new, larger organizational forms could predominate forcing lower technology operations out of business.

However, such new organizational forms may have positive, negative, or mixed effects on small agribusinesses or producers. New technologies and better communication are spawning many joint ventures, coalitions, and licensing arrangements so that allied firms may cooperate in new ways both horizontally and vertically. Baarda's idea of the transgenic firm is such an example [Baarda, 1999]. The idea of the transgenic firm arose in biotechnology, where developers of new transgenetic plants and animals sought a new vertical legal arrangement to protect their intellectual property from horizontal spread to non-paying customers. Previously seed manufacturers or breeding operations may have been willing to sell farmers or ranchers seed or semen without restriction. Now, they are offering restricted use of patented life forms they do not own for a single planting or breeding cycle. The owner of the patent required a new legal form of control to prevent unauthorized replication of patented material.

In the same way, information providers try to protect their intellectual property from unauthorized duplication and distribution to parties who have not paid for it. Obviously, information cannot be bred to produce future generations of information the way that a genetically engineered plant or animal can. However, producers of weather reports, farm advice, and marketing research have a similar desire to avoid unauthorized replication of their intellectual property in the very short run, rather than the short run or long run. Ciborra argues this is no surprise in either case since coalitions "will be more frequent during periods of rapid and significant structural change in an industry." [Ciborra, 1992, p. 93] Indeed, the Internet, e-commerce, and hypercommunications in general have led to the establishment of new kinds of business arrangements such as affiliates, strategic partnerships, and other co-operative forms of governance that fall far short of mergers and acquisitions.

In general, agribusinesses will use hypercommunications networks when it is worthwhile to do so. Lawton (1997) provides six guidelines as to when a business will adopt or join a network. The first guideline is: "A network will only be used by a firm if it is the least costly alternative for the delivery of a particular service or set of telecommunications services." [Lawton, 1997, p.139] The truth of this statement seems tautological until it is realized that it applies to a full information case given a competitive market.

It can be easily asserted that, like other non-information sector firms, most agribusinesses (especially firms with fewer than fifty employees) may not know many technical characteristics regarding network services and technologies. It may be true that an IP CTI VPN (advanced converged network discussed in 4.5.4, 4.7.2, and 4.9.7) could replace the office telephone system for a much lower cost with tremendous positive network effects. However, the technical details necessary to understanding all that entails (and especially how reliable the new network will be) requires enormous effort to absorb.

The second guideline to economically predict the adoption of communication networking technology is: "A firm will build, rent, or otherwise obtain its own facilities-based network when to do so is less costly than the use of existing commercially available networks." [Lawton, 1997, p.139] Again, the agribusiness may be left at a disadvantage because of knowledge. However, some large and small agribusinesses have already created their own hybrid networks such as on-premises unlicensed spectrum wireless or other informal solutions. Most firms have neither the financial nor technical resources needed to create their own networks, even though this is technologically possible in a virtual sense.

The third guideline states that "A network is the least cost alternative for the delivery of certain telecommunications alternatives." [Lawton, 1997, p. 139] This guideline summarizes one of the central lessons of Chapter 3. Beginning with line consolidation and hierarchical routing and leading up to packet-switching, multiplexing, and virtual circuits, the chapter has traced how networking technology has been able to cram more information onto less wiring over greater distances at lower costs. On the surface, the idea seems counter-intuitive for agribusinesses as well as economists. However, the more educated an agribusiness becomes, the greater the chance that it will realize that if some networking is good, more networking can be better, etc.

The fourth guideline reads "A point-to-point network or sub-network is the least cost alternative for the non-ubiquitous delivery of certain telecommunications services." [Lawton, 1997, p. 140] A business may be able to save money and gain security by shrinking the connections made to some machines, databases, or stations. Some kinds of sensitive, highly confidential traffic for businesses such as payroll data, customer data, and orders do not gain anything by being transported over inexpensive multi-level inter-networks. While connection charges can be lowered, there are cases where the most expensive connection will be the least expensive in terms of overall economic costs when risk is considered.

The fifth guideline is "All services use the network in order to obtain the network surplus." [Lawton, 1997, p. 141] The theoretical truth of this statement is masked by lack of information, unequal infrastructure development, and the fact in the marketplace (not counting certain rural areas) multiple carriers peddle multiple services on multiple networks.

The full information argument and competitive marketplace could also be analyzed from the hypercommunication vendor's point-of-view. It is to the carrier's benefit to see that customers are confused enough by the details of communications networks that they hire the carrier as their agent and not just as a service provider. That way, separate bills for separate networks for separate services will continue to be the rule. Even as carriers see that it is cheaper for them to merge some networks, bills, and services many carrier personnel are confused by the array of technical details and rare situations that arise in telephony, data networking, and Internet.

The sixth and last guideline that explains the economic conditions that favor businesses network adoption is that "A network is integrated and indivisible." [Lawton, 1997, p. 143] On this guideline, the agribusiness may gain caution. While many of the other guidelines can be interpreted almost as positive commands for agribusiness managers to join new kinds or more powerful networks, beneath the positive integration and indivisibility of this guideline lurks genuine danger. Specifically, there are concerns about security, reliability, and dependency. These are addressed throughout Chapter 4.

3.8 Summary

Chapter 3 has discussed *why* hypercommunications have originated by tracing the technical properties of communication networks. As the PSTN and private data networks developed, the engineer's view of networks as an efficient service delivery mechanism serving passive subscribers was emphasized. However, the combination of OR's technical capacity to optimize converged networks and the reasons *why* hypercommunications originated from the information economy (covered in Chapter 2) created a new network economics. Instead of replacing conventional economics or repudiating the engineering economics, the new economics that was born from the technical realities of network synthesizes past work in technical and economic efficiency with network effects.

While there are many conceptions of networks, the converged hypercommunication network of the near future will rely on interconnected digital transmission of data and information over an inter-network of voice and data sub-networks. Economic implications of how hypercommunications work rely on larger conceptions including fuzzy inter-personal networks and broader macro networks.

Table 3-6 summarizes the results of Chapter 3 by comparing the economic characteristics of several kinds of networks. The telephone access level is not actually part of a network as much as it is a connecting system. Network access remains an important concept when Chapter 4 begins the process of identifying *what* hypercommunication services and technologies are. As network development progressed, the access loop and even the devices used to communicate over networks became part of the network. However in most cases, access level connections are still paid for separately from other network services. Access connections remain major barriers to high-speed networking, especially in rural areas.

Table 3-6: Comparison of economic network characteristics.

Network	System ownership	Network ownership	Connecting nodes
Telephone access	NA	ILEC owns access loop. Loops are wholesaled to ALECs or IXCs. Retailed to firms.	Subscriber CPE connects to ILEC, ALEC, or IXC CO.
Telephone transport	Formerly AT&T, now multiple carriers	Inter-network of ILECs, IXCs, ALECs.	Switches and conduit owned or leased by telco
Centralized computer	NA	Firm unless time-sharing	NA
LAN	NA	Firm	Hubs, other DCE owned by firm
Client-server WAN	Telco or ISP	Firm owns local portion, leases dedicated access from telco.	Routers or other CPE DCE
Distributed network	Telco or ISP	Firm owns local portion, some remote nodes, leases access loop and connection circuit separately.	Servers, routers, switches, other DCE.
Inter-network computer	System of telcos, NSPs & ISPs	Only local portion owned by firm, access and connection leased separately.	Servers, switches, gateways, other CPE.

The telephone transport network has evolved from a hierarchical system developed by AT&T into interlocking cost-sharing and redistributory networks of separate long-distance and local carriers. As computer networks, digitization, and de-regulation occurred, the transport network became parallel networks of different local and long-distance carriers. Now with the advent of IP transport, the telephone transport network is becoming a pluralistic inter-network that is shared, but not entirely owned by any party. Many carriers do not even have transport facilities.

Several economic generations of computer networks were covered in Chapter 3. These moved from ownable centralized computer and LAN systems to virtual inter-networks that used pluralistic peering arrangements to move traffic over long distances for insignificant unit costs. As Chapter 4 will show, hypercommunication services and technologies rely more on the distributed or inter-network forms than their predecessors. However, ownable CPE networks (such as LANs and telephone systems) are able to interconnect and gain full network benefits.

CHAPTER 4
HYPERCOMMUNICATIONS CONVERGENCE: SERVICES AND TECHNOLOGIES

> Historically, the telephone network carried public voice communications, private corporate networks delivered data, and broadcast networks delivered video. Each of these services was coupled with a specific form of infrastructure, such as copper pairs for telephone or coaxial for cable TV. Digitalization of voice, data, and video information . . . has allowed traditional boundaries to be crossed relative to services being provided. In other words, a single facility carries voice, data, and video. . . . With the digitization of information, the network needed for transport requires only digital transmission capabilities. Legacy networks designed for specific technologies are in the process of transformation to allow provision of all types of services. [Weinhaus, Stevens, Makeeff, *et al.*, 1998, p. 26]

The objective of Chapter 4 is to show *what* hypercommunication technologies and services are. However, distinguishing hypercommunication services from hypercommunication technologies can be a difficult task. As Weinhaus, Stevens, Makeeff, *et al.* noted above, separate legacy (existing) communications networks are evolving into unified digital networks capable of transmitting all kinds of hypercommunication services, a process known as convergence. Convergence complicates the task of differentiating hypercommunication services from the network and delivery technologies that provide them.

Charles Sirois explains three trends that are altering traditional distinctions between services and technologies:

> . . . First, there is a deregulation trend. . . . The second trend is the feasibility of splitting telecommunications infrastructure from services. Where this occurs, it means that for every dollar spent on telecommunications services, the infrastructure portion will be smaller. In the past, the infrastructure was the service when you heard the dial tone after picking up the telephone. What . . . telcos provided was mainly a pair of copper wires and a number of switches. The

> infrastructure was the service. ...The telcos were only in the carriage business. They could not be in the content or message business.
>
> Today it is possible to be a telecommunications service provider without owning one inch of fibre optic cable or even a switch. The necessary hardware can be leased from facilities-based operators like the telcos. ...So more and more you can have a split between infrastructure and services.
>
> These two trends lead to a third one: fragmentation of the offerings to the end-user. We are not talking here of oligopoly. Rather, in the future there will be hundreds or even thousands of providers of telecommunications services (i.e. content). It will be a world of specialists, focusing on hundreds of niche markets. This is the world of narrow-casting . . . and the many service providers will have a choice of methods of transmission to reach their niches. [Sirois, 1996, pp. 198-199]

These three trends (deregulation, the service-technology distinction, and fragmentation) will become increasingly important to how agribusinesses buy hypercommunications. In this Chapter, the service-technology distinction and the fragmentation of offerings to business customers are covered. Regulatory issues (especially important to agriculture and rural areas) will be considered in Chapter 5.

Agribusinesses buy hypercommunication services from hypercommunication suppliers. However, if Sirois is right, in spite of convergence, "fragmented" services and prices (which vary by network technologies and content) will confuse agribusinesses. Furthermore, carriers use many different hypercommunication technologies to reach the locations agribusinesses need for communication. These technologies include transmission technologies, infrastructure technologies, interconnection facilitating technologies, or voice-data consolidation technologies. Each technology, in turn, may be composed of hardware, software, conduit, and protocols.

Specific technologies may seem unimportant to agribusiness managers when they need no technical knowledge of the underlying network in order to communicate. However, the strengths and weaknesses of particular technologies become important if there are frequent interruptions (downtime), if costs skyrocket, or if rural areas will not be served. Additionally, agribusinesses can choose technologies tailor made to specific strategies. Finally, agribusinesses also rely on capital purchases of hypercommunication CPE (Customer Premise Equipment). CPE technologies include computers, faxes, telephone systems, and other devices. CPE must be compatible with the existing equipment and software of both the agribusiness and its hypercommunication vendors. Additionally, an agribusiness may need hypercommunication services such as programming, web design, Internet promotion, repair, technical support, or network planning.

Basic knowledge of *what* hypercommunication services and technologies are could help an agribusiness manager simultaneously save money, improve communications with existing customers, plan future needs, and reach new customers. This Chapter provides descriptions of the major hypercommunication services and technologies that are available (or shortly will be) to Florida agribusinesses.

Organization of Chapter 4 is straightforward. Section 4.1 covers ways that hypercommunication services and technologies are converging into a single market. Section 4.2 discusses QOS (Quality of Service) and the many popular definitions of bandwidth. Bandwidth, data rate, throughput, and delay are often lumped together under a popular definition of bandwidth even though they are examples of individual QOS metrics that objectively appraise separate parts of hypercommunications quality and quantity. The next sections differentiate hypercommunication transmission technologies between wireline (4.3) and wireless (4.4). Section (4.5) touches on hypercommunication support services, facilitation, and consolidation (convergence-enabling) technologies. Then, hypercommunication services and technologies related to specific services are divided into four sub-markets: traditional telephony (4.6), enhanced telecommunications (4.7), private data networking (4.8), and Internet (4.9). The Chapter concludes with a summary comparing the usefulness of transmission technologies and service groups to agribusiness (4.10).

Chapter 4 uses technical sources (articles, texts, white papers, and standards) to provide overviews of the three global technological areas and four specific service sub-markets. Further details came from trade publications and informal discussions with industry sources. Where possible, deployment of services was examined firsthand in businesses around Florida. History provides the basis for constructing the three global technology sections and four specific service sub-markets. Now, each sub-market represents a share of the converging hypercommunications market.

There is a danger to approaching hypercommunications through historically defined sub-markets because that view emphasizes regulated monopolies such as telephone ILECs and cable TV providers. Both federal and state regulatory environments have changed dramatically in the past five years. Thinking about separate services and technologies (using *either* the interpersonal *or* mass communication model alone) does not apply now as it did when the 1934 Communications Act (the organic legislation to the 1996 TCA) became law. In the year 2000, the hypercommunications infrastructure consists of the PSTN, the Internet backbone, private data networks, along with "dark fiber" and other landline infrastructure (such as cable television systems). Additionally, terrestrial and satellite wireless networks form part of the hypercommunications infrastructure.

4.1 Hypercommunications Convergence

Although the hypercommunication model is replacing the formerly separated interpersonal and mass communication model with a myriad of interconnected choices, convergence is not yet a reality. Hence, while there is some danger in using sub-markets to characterize what hypercommunication services and technologies are, Chapter 4 is best organized around the current structure of hypercommunications. Convergence is the process that will modify today's sub-markets into tomorrow's converged marketplace. It is therefore appropriate to begin by naming dimensions of convergence that are affecting the technologies and sub-markets that form the basis for the rest of Chapter 4.

Virtually every segment of the world's economy (including agriculture) is affected by the convergence of basic telephony, enhanced telecommunications, the Internet, and private networking into hypercommunications. While the inevitability of convergence is taken for granted, the rate of convergence and the form it will take cannot be. Convergence would happen automatically except for institutional and attitudinal barriers including regulation, competition, speed of diffusion, and competing standards. Converge means "to move, turn, or be directed toward each other or toward the same place." [*Webster's New World Dictionary*, 1960, p. 323]

In a rapidly expanding marketplace with frequent introductions of new services and technologies, convergence means that further horizontal and vertical integration of the hypercommunication market will occur with profound implications for individual agribusinesses. Convergence has already been described as a process where two separate communications models (interpersonal and mass) and their separate telecommunications networks evolve into a single hypercommunications model that uses a mesh of networks.[1] This view matches Alan Stone's definition of "boundary problems" due to the clash of old and new technologies. According to Stone, the first boundary problem was telephone-radio, followed by telephone-computer, TV-radio, etc [Stone, 1997]. Instead of entirely replacing the old technology such clashes can lead to new uses for the old technology. For example, radio had been expected to die because of television and the demise of movie theatres was expected because of VCRs. In both cases, the market was able to absorb the new technology without eliminating the old.

However, because of the diversity of hypercommunication services and technologies it is difficult to speak of boundaries in the same breath as convergence. Instead of discrete boundaries, convergence has analog dimensions. For agribusiness, hypercommunications convergence has five similar dimensions, each based on a clash between old and new. Each dimension is important to agribusiness because the result of the clash will determine capital costs and variable expenses.

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[1] See Figure 2-3 in Chapter 2.

The first dimension of convergence is device-device convergence, the convergence of previously differentiable electronic hardware devices into multi-purpose units. The telephone, fax, television, radio, and computer are beginning to converge together into DTE (Data Terminal Equipment), or multi-functional user devices. As one newspaper article put it:

> 'Convergence is the coming together of computer, broadcast, telecommunication and entertainment technologies. It fulfills the ultimate promise of the information revolution --- the ability to receive [and process, store, manipulate] any information anywhere with a single [intelligent] terminal.' [*The Globe and Mail* (Toronto, Ontario), June 26, 1994, p. B4]

Already, employees of an agribusiness may use several separate communications devices (telephone set, fax machine, desktop computer) or sit at a CTI (Computer Telephone Integration) station with fax, e-mail, computing, Internet, video, and voice capabilities. George Gilder argues that convergence is being driven by "the on rush of computer technology invading and conquering" the traditional distinct domains of television, films, consumer electronics, telecommunications, publishing and games [Globerman, Janisch, and Stanbury, 1996, p. 212].

The main question is whether the computer will completely replace the office telephone, fax machine, and copier. Device-device convergence is becoming increasingly important as agribusinesses equip offices and train employees. While there can be substantial savings to capital budgets from purchasing one device to do the job several previously did, a dangerous dependency on a single technology or connection can occur unless there are redundancies. For example (unlike a computer terminal), individual telephone sets do not become useless every time a computer spreadsheet crashes, nor do telephones suffer downtime during every LAN outage.

A second dimension of convergence is content-carrier convergence. Content-carrier convergence is also called confluence:

> What is widely called convergence (but should more properly be called confluence) has resulted in the blurring of the traditional distinctions between telecommunications and broadcasting, and between content and carriage. [Globerman, Janisch, and Stanbury, 1996, pp. 212-213]

MS-NBC is one example. A broadcast carrier (NBC) and an ISP-software giant (MSN, MicroSoft WebTV) combined through a "strategic alliance" to create editorial content, advertising tie-ins, and common e-commerce opportunities designed to meld formerly diverse content services into commonly controlled programming and distribution. The Time Warner-Turner Broadcasting-AOL-Netscape mega-merger is another example. When a hypercommunications carrier creates content under content-carrier convergence, it can prevent or outmaneuver other firms from offering content or access. One example of how this works is through web portals. A web browser can be programmed to go to a particular home page (portal) upon session initialization.[2] Wireless devices are factory programmed to exclusively access portals where the carrier has control over content. If carriers obtain enough market power to lock out competing content providers, consumers have fewer choices and agribusinesses can become dependent on a single source for news, information, and communications access. For some rural areas, the situation is already familiar. In many local areas of Florida, AOL is the only possible way to obtain Internet access, though this is less true than it was.

The third dimension of convergence, carrier-device convergence occurs when the hypercommunications carrier and the communications device used to communicate become the same. An extreme example of carrier-device convergence was used by pre-breakup AT&T. Telephone customers had to lease telephones from AT&T that were manufactured by AT&T's Western Electric subsidiary. A recent consumer action against AOL is another example. The plaintiffs charge that once Internet Explorer for AOL was installed, it became impossible for the computer to be used to access a competing OSP or ISP if the consumer switches providers. The inter-relatedness of hypercommunications technologies can mean that a service provider will be unwilling or unable to provide services if an agribusiness already owns a certain make of equipment or is located in a particular area. Substantial switching costs to change providers can occur in this way.

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[2] Over two-thirds of customers do not change the portal or splash page even when software allows it. In some cases, no choice is available or changes are complicated for users to make. For example, Netscape Communicator (version 4.7) mailboxes open to a content page the user cannot change unless careful text editing is done to the preferences file.

In the fourth dimension, regulatory convergence, as separately regulated industries come together, so will taxes, regulations, and governmental policy. Quoting George Gilder again, Globerman, Janisch, and Stanbury state what is behind regulatory convergence:

> Also, 'convergence assaults century-old regulatory rules that have kept telecommunication and broadcasting in separate legal solitudes. The old distinctions were based on the types of wire, of radio signals, of information and of companies. These barriers no longer make sense.' In fact, convergence would not be a public policy issue if it did not cause conflict among previously separate regulatory regimes, telecommunications, and broadcasting. [Globerman, Janisch, and Stanbury, 1996, p. 213]

Because of delays introduced through the lobbying, legislative, regulatory, and legal processes, market adjustments typically occur so quickly that regulatory action can be superfluous. However, regulation may inhibit convergence from occurring or prevent service providers from entering rural areas until regulatory issues are resolved. Other areas of regulatory convergence such as taxation are covered in Chapter 5.

The regulatory task becomes more difficult as new services and technologies, (especially the unregulated Internet) create new regulatory territory.

> Convergence also includes the ability to combine several technologies to produce new modes of communication. For example, the Internet or (network of networks) combines computers (largely PCs), modems, specialized software, existing telephone lines, packet switching, and a universal transfer protocol (TCP/IP). The result has been a very rapidly growing mode of communications, which in the past two or three years began to evolve from being text-based to sound (including a crude form of telephony) and video. When broadband capacity cable or wireless replaces the twisted pair of copper wires over the last mile, the Internet may be the epitome of convergence. [Globerman, Janisch, and Stanbury, 1996, p. 212]

The fifth dimension of convergence is competitive convergence (market convergence). This dimension is defined through market structure, conduct, and performance. When firms merge or technologies converge the number of firms is reduced. Hence, convergence

> . . . refers to any break-down of previous technological barriers among computer software, telephone, cable and entertainment industries. Those barriers arose from the limitations inherent in pre-computerized analog signaling. Convergence is a technological phenomenon, but its wider consequences are being felt by individual businesses, by regulators, and by consumers. [Globerman, Janisch, and Stanbury, 1996, p. 212]

There is an inherent tension between the rates of growth of pro-competitive influences and anti-competitive influences. Pro-competitive influences (deregulation, elimination of regulatory monopolies, uniform taxation across sub-industries, IPOs, spin-offs, interconnection, etc.) stand opposed to anti-competitive influences (technical convergence, mergers, re-regulation, and non-uniform taxation across sub-industries).

The changes convergence is bringing promise to be truly revolutionary according to Gilder:

> 'The computer industry is converging with the television industry in the same sense that the automobile converged with the horse, the TV converged with the nickelodeon, the word processing program converged with the typewriter, . . . and digital desktop publishing converged with the linotype machine and the letterpress.' [Quoted by Globerman, Janisch, and Stanbury, 1996, p. 212]

However, there is a difference of opinion of how soon the convergence revolution will occur as shown by two *Internet Week* headlines: "The One Pipe Approach Gains Momentum"[3] and "Convergence Reality Check: Voice Data Unity Still a Pipe Dream".[4] In the 1999 convergence reality check article, an *Internet Week* survey found that only eleven percent of IT managers surveyed already had converged networks while sixteen percent planned to unify their voice-data networks within one year. However, fifty-one percent had no convergence plans or were planning to wait at least three years.

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[3] *Internet Week*, October 5, 1998, pp. 27-29.

[4] *Internet Week*, March 22, 1999, pp. 1, 55.

An important barrier to convergence is the lack of SLAs (Service Level Agreements) or signed contracts between buyer and seller setting out QOS guarantees. "The realization of a multiservice utopia will not happen until service guarantees become a fundamental part of the convergence landscape." [Morency, 1998, p. 23] The increasing importance of hypercommunication SLAs means agribusinesses need to be intimately familiar with bandwidth and other QOS metrics that establish SLA terms. Bandwidth and QOS metrics are the weights and measures of hypercommunications, but are hardly as standardized as those agribusinesses are used to in other markets.

4.2 Bandwidth and QOS (Quality of Service)

No hypercommunications term is subject to more confusion or used more frequently than bandwidth. While an understanding of bandwidth is important to agribusinesses hoping to use hypercommunications services and technologies, bandwidth is not a complete description of the speed, overall quality, or value of a particular service or technology. Bandwidth-related measures are most often used to define and price hypercommunications services and technologies. However, excess reliance on one term obscures a more comprehensive set of characteristics called QOS (Quality of Service) metrics that are more important to agribusiness hypercommunication strategies. This section is designed to be a practical guide for agribusinesses hoping to understand bandwidth and other QOS so as to become more informed hypercommunication buyers.

This section and the following three (4.3 through 4.5) apply generally across the specific service and technology sub-markets discussed the last half of the Chapter from 4.6 through 4.9. To provide the right technical foundation, large amounts of supporting technical details are presented here in section 4.2. Readers who are already familiar with signal conversion, how modems work, and the subtleties of bandwidth, throughput, and data rate may go directly to (4.2.3). There, a general QOS model is introduced to provide an analytical framework of agribusiness hypercommunication networks. The reference model integrates QOS metrics and bandwidth with material from Chapter 3 such as the three core engineering problems of communication networks[5] and the four technical objectives of network managers[6].

Other readers may need to take advantage of all four sub-sections in 4.2, being aware that tables 4-1 through 4-4 and figures 4-1 through 4-22 trace the main points, with the text available for additional support. In the first sub-section (4.2.1), bandwidth and five other QOS characteristics most often confused with bandwidth are discussed. The critical distinction between signals and messages and the difference between operational speed and capacity are explained. Then, a practical example of computer modem communication (4.2.2) underscores bandwidth's separateness from other QOS metrics. The last section (4.2.4) presents agribusinesses with a thumbnail sketch of the QOS dimensions used in buying and selling hypercommunication services and technologies.

4.2.1 The Relationship between Bandwidth and Speed

For several reasons, bandwidth has taken on an imprecise meaning that goes beyond its specific technical definition as a capacity measure (as introduced in Chapter 3). One reason for this is that the technical nature of hypercommunications tends to be confusing. Technical terms such as bandwidth become confused with closely related technical terms. A second reason for the overuse of bandwidth is that bandwidth is the unit most often used to price hypercommunications services and to describe infrastructure, networks, and individual connections. This multiplicity of uses causes instant misunderstanding since bandwidth is variously used as a stock measure, a flow measure, an accounting cost, and a capacity constraint. In short, bandwidth is used popularly to compare the speed, capacity, reliability, and quality of hypercommunication services, carriers, and technologies.

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[5] From Chapter 3, the three core engineering problems were combinatorial, probabilistic, and variational.

[6] The four technical objectives of network managers (also from Chapter 3) were sending rate control, conduit signal modulation rate, overall network optimization, and receiving flow control.

Furthermore, there is a lack of uniformity in "expert" opinion[7] about what bandwidth is. As more sources are consulted, more variations in definition are encountered. For example, a well-received book aimed at business MIS and telecommunications managers defines bandwidth as "the speed with which data travels, measured in bits per second (bps)" [Bezar, 1995, p. 75]. However, in Bezar's glossary bandwidth becomes:

> ...A term defining the information carrying capacity of a channel ---its throughput. In analog systems, it is the difference between the highest frequency that a channel can carry minus the lowest, measured in hertz. In digital systems, the unit of measure of bandwidth is bits per second (bps). The bandwidth determines the rate at which information can be sent through a channel --- the greater the bandwidth, the more information that can be sent in a given amount of time. [Bezar, 1995, p. 421]

The distinction between digital and analog discussed in 3.2.1 helps explain the multiple meanings of bandwidth.

However, the meaning of bandwidth also depends on the relationship among bandwidth, bits, and speed, a complex recipe with three main ingredients. First, a hypercommunications message (voice, data, or video) and the signal that carries it are different entities. Signals can be analog or digital while message content also can be analog or digital. Second, signal transmission may use broadband technology, carrierband technology, or baseband technology. Third, there can be a difference between the upstream and downstream rate and capacity (directional asymmetries) for a variety of scientific and technical reasons. These ingredients need to be examined before QOS can be understood.

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[7] The author is no expert himself, nor is this work capable of definitively defining bandwidth since the real experts disagree. However, because of the practical intent here, pigeonholing of ideas into terms has been necessary. Regardless of terminology, the separate concepts identified are important considerations for agribusinesses seeking to buy hypercommunications.

The first ingredient is the distinction between signal domain and message content. The signal-message distinction is rooted in Shannon's mathematical theory of communication, shown in Figure 4-1 [Shannon, 1948; Shannon and Weaver, 1949].

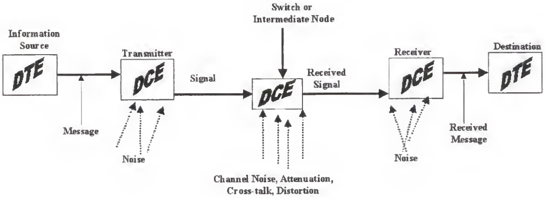

Figure 4-1: Shannon's schematic of a communications system.

The information content of a message[8] and the domain of the signal are two distinct entities. Messages may have either analog or digital information content (source domain) depending on the equipment (DTE) at the information source and destination. Information sources "represented by a physical quantity that is considered to be continuously variable and has a magnitude directly proportional to the data" are analog [GSA, *FED-STD-1037C*, p. 1996, A-14]. Analog message content refers mainly to voice telephone calls, though it can include audio, graphics, video, and readings from scientific sensors (such as pressure, temperature, and position). Digital information sources are "represented by discrete values or conditions (or) are discrete representations of quantized values of variables, e.g., the representation of numbers by digits perhaps with special characters and the 'space' character." [GSA, *FED-STD-1037C*, 1996, p. D-18] Digital message content includes almost all data communications and Internet traffic.

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[8] Mathematically, information content, message content, and data content are synonyms for content (source) domain.

The advent of digital cameras, digital image scanners, CDs, etc. has created digital replacements for previously analog sources.

The signal is an electric current or electromagnetic wave used to carry an encoded representation of the message from the transmitter to the receiver. Signals may be digital or analog depending on the transmitting and the receiving equipment DCE (Data Communications Equipment) on each end as shown in Figure 4-1. According to Hill Associates, "Signaling is analog if the *signal transmitted* can take on any value in a continuum . . . Signaling is digital if the *signal transmitted* can take on only discrete states." [Hill Associates, 1998, p. 303.1.3, italics theirs] Switches, routers, and other kinds of intermediate DCE must be in the same domain as the signal or signal conversions must occur. If necessary, signals are decoded into the appropriate source domain before reaching their destination.

Digital signals offer many advantages over analog ones. For example, many separate digital signals may be interleaved and sent together to permit several separate conversations on a single line (multiplexing). Digital messages can be encrypted before their transmission as signals to prevent eavesdropping and to provide security. Often, severely degraded digital signals may be reconstructed, providing perfect copies of the original source. However, excess interference can prevent an entire digital signal from reaching a source, while distorted analog signals would be garbled but received under similar conditions. Digital signals require more bandwidth than analog signals do, but they are still less costly to transmit [FitzGerald and Dennis, 1999].

Table 4-1 shows the four combinations of digital or analog information content and analog or digital signals. Since each combination has different physical characteristics, each kind requires specialized hardware. These combinations also apply to signal-signal conversions and intermediate transformations that can occur in the transport level of a communication network, especially over long distances. Table 4-1 and Figure 4-1 show that Shannon's (1948) "information source" and "destination" are now known by the more general term, DTE. In a purely discrete system DTE are digital. In a purely continuous system DTE are analog. In a mixed system, DTE can be digital or analog.

Common digital DTE devices include computers and certain digital telephones[9]. These devices send and receive digital messages whether text files, e-mails, voice mail, or graphics and video. Common analog DTE devices include most telephones, microphones, speakers, and certain scientific instruments.

Table 4-1: Mapping from source domain to signal domain.

From: source domain (cols.) To: signal domain (rows)	From: Digital Sources (bits) (Digital Message Content)	From: Analog Sources (Hz) (Analog Message Content)
To: Digital Signal (bps)	(Purely discrete system) Digital-Digital transformation DCE example: DSU/CSU Function: map discrete states of information domain onto discretely varying signal domain.	(Mixed system) Analog-Digital conversion (ADC) DCE examples: Codecs (Coder-Decoders) or Digitizers (ADC) Function: map continuous states of information domain onto discretely varying signal domain. Has quantizing error.
To: Analog Signal (Hz)	(Mixed system) Digital-Analog conversion (DAC) DCE examples: Modems (DAC is modulator) or Interpolators (DAC) Function: map discrete states of content domain onto continuously varying signal domain.	(Purely continuous system) Analog-Analog transformation DCE example: POTS (transducer) Function: map continuously varying states of content domain onto continuously varying signal domain.

The receivers, transmitters, and switches of Shannon's communications system also are generalized by the term DCE (Data Communications Equipment or Data Circuit-terminating

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[9] Most "digital" phones capture the analog source with a microphone and use an internal DSP (Digital Signal Processor) to convert the source into digital form which is then sent as a signal. On the receiving side, a truly digital phone transmits voice digitally through the receiver instead of performing a DAC before the signal reaches the earpiece.

Equipment).[10] DCE are specific to the signal domain (analog or digital) while DTE depend on the message domain as well. The two need not be separate devices from the user's point-of-view.

DCE transmit and receive each end of a hypercommunication (and often in between) in the appropriate signal domains. A common DCE example is a computer modem. A modem is a transmitter that modulates digital content into an analog signal on one end and a receiver that demodulates analog signals back into digital form to reach the destination. Similar DCE devices exist for other signal domain, source domain combinations. For example, codecs (coder-decoders) are circuits (or software) serving as built-in DCE used to make conversions within digital DTE.

Therefore, in some cases such as telephones (both analog and digital), DTE and DCE are in the same device. For example, an analog telephone contains a microphone to capture the analog voice source that is then converted by a transducer into electronic waves that are sent as analog signals.

Figure 4-2 (direction of communication read from left to right) depicts signal conversion or transformation for the four cases alluded to in Table 4-1. In a purely continuous system (upper right, Figure 4-2), analog messages are modulated onto analog signals (continuously varying representations of the source message) over a carrier wave as in the cases of POTS and traditional broadcast radio and TV. A carrier is signal with known characteristics that is modulated to carry information. Using a carrier, the receiver can extract the message because it knows the characteristics of the carrier wave. However, noise or unintended changes to the carrier will be interpreted as part of the information. The bandwidth (transmission capacity) of channels over which analog signals pass is the difference in Hertz (cycles per second) between the minimum and maximum frequencies.

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[10] This DCE and DTE definition is more general than some authors' because it is a computer networking term that has been applied to hypercommunications. Those who favor DCE as data circuit terminating equipment argue that DCE must directly connect to DTE via an RS232 (EIA-232) connector, ruling DCE out as network devices. Due to the importance of networks (and rather than add to the jargon load), DCE as data communication equipment has gained recent favor.

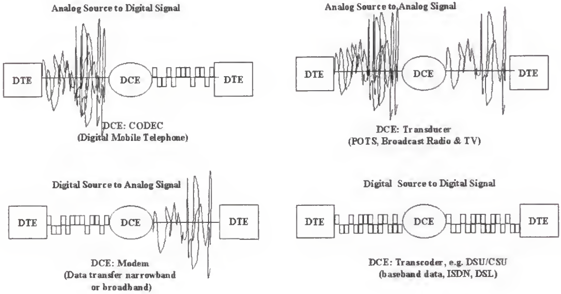
Analog Source to Digital Signal
DTE
DCE
DTE
DCE: CODEC
(Digital Mobile Telephone)
Analog Source to Analog Signal
DTE
DCE
DTE
DCE: Transducer
(POTS, Broadcast Radio & TV)
Digital Source to Analog Signal
DTE
DCE
DTE
DCE: Modem
(Data transfer narrowband
or broadband)
Digital Source to Digital Signal
DTE
DCE
DTE
DCE: Transcoder, e.g. DSU/CSU
(baseband data, ISDN, DSL)

Figure 4-2: Simplified Signal Conversion and Transformation.

A purely discrete system (shown in the lower right of Figure 4-2) features a digital source carried by a digital signal (coded word representation of the source message) as in the case of Ethernet, ISDN, and DSL. With digital signal transmission, bandwidth is expressed in a bit rate (bits per second, bps). Bandwidth is expressed in Hertz (Hz, cycles per second) for analog-analog transformations.

However, the best unit to express bandwidth in is often confused between bps and Hz for the other two cases (mixed systems) when conversion (rather than transformation) occurs. In DAC (Digital source to Analog signal Conversion), shown on the lower left of Figure 4-2, the digital domain of the message is mapped onto an analog signal domain in order to reach the destination[11]. In ADC (Analog source to Digital signal Conversion), shown in the upper left of Figure 4-2, the analog domain of the message must be mapped onto a digital signal domain. In such mixed systems, both Hz and bps may be used to describe bandwidth, depending on the context.

In ADC, analog messages may be converted into digital signals through codecs (coder-decoders) to become signal pulses. Typically, these pulses are modulated over a carrier pulse as in the case of digital wireless mobile telephone. Computer modems and cable modems perform both ADC and DAC. A modem modulates digital data (messages) into analog signals when it sends and demodulates analog signals to digital data when it receives. There can be several such signal conversions at intermediate DCE between the sender and receiver.

Analog signal modulation refers to alterations made by DCE in the characteristics of analog carrier waves, impressed on the amplitude (signal strength), phase (wave phase) and/or the base frequency of the wave. Analog signals (continuous waves) may be modulated (coded) in several methods including AM (Amplitude Modulation), FM (Frequency Modulation), PM (Phase Modulation), and QAM (Quadrature Amplitude Modulation).

Digital signals (discrete pulses) are modulated (encoded) through various kinds of PCM (Pulse Code Modulation) such as PAM (Pulse Amplitude Modulation), PDM (Pulse Duration Modulation), and Pulse Position Modulation (PPM). Digital signals are aperiodic (non-repeating patterns) so frequency cannot be used to describe them. However, a digital signal can be approximated by an n-th order series of harmonic sine waves. Each harmonic has its own amplitude, phase, and frequency. The minimum significant spectrum is the minimum frequency range (frequency spectrum) needed to represent the original signal and n-th order harmonics. The bandwidth of a signal is the width of the frequency spectrum it occupies.

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[11] In Figure 4-2, the destination is a DTE directly connected to the same DCE that performed the conversion from the source. In most cases, the signal must travel from one DCE to another over a network until it reaches the destination site where the last DCE converts it into the message form required by the source DTE. In other cases, DTE and DCE may be in the same device for one end of a conversion, but different devices at another end.

When expressed in Hertz, the bandwidth of an analog medium for a digital signal provides a range of frequencies that can be transmitted. If this range is smaller than the minimum significant spectrum, more bandwidth is needed to allow the receiver to reproduce the original source signal.

When the end-to-end observed speed of communication between sender and destination DTE is considered, other characteristics beyond the bandwidth (capacity) of a single link or the bit rate of a given DCE are involved. These characteristics (summarized in Table 4-2) include throughput, data rate, delay, and jitter. Importantly, the focus of the first four characteristics in the table (each of which is often misleadingly called bandwidth) is primarily on digital bits.

Table 4-2: Bandwidth and QOS measures with which it is most often confused.

Item	Units	Scope	Measures
Bandwidth	Analog (Hz) Digital (bps)	Single Link or Point-to-Point (DCE-DCE, transmission link only)	Signal carrying capacity of a segment(s) of a communications link. Width of communications link.
Bit Rate	bps	DCE operational speeds	Baud rate x $\log_2 n$, or the operational speed of DCE with $\log_2 n$ code bits (n-level coding)
Data Rate	bps_t	Single Network Link or multiple channel traffic between DCEs	Error-free aggregate speed at a point or through a segment. Includes overhead.
Throughput (pure or effective)	Max(bps) or bps_t	End-to-End (sender DTE through receiver DTE)	Pure (maximum) throughput: End-to-end transmission capacity of user information from sender to receiver. Observed (effective) throughput or throughput rate: rate at which system processes and transmits user information (does not include overhead).
Delay	ms_t	End-to-End (DTE to DTE or DCE to DCE for troubleshooting)	Time it takes a bit to move across transmission time. Length of communications link.
Jitter	$ms_{t,t+n}$	End-to-End (DTE-DTE or DTE-DCE)	Variation in delay. Descriptive statistic.

When expressed in Hertz, bandwidth represents the raw capacity of a noiseless, analog channel before digital data are imposed. When expressed in bps, bandwidth represents the maximum attainable bit rate in a single direction of a noiseless link with no other traffic. The bandwidth or more precisely bit rate associated with a given bandwidth in Hz depends on the baud rate and coding rate. A sampling or baud rate is directly proportional to the bandwidth. The coding rate (number of levels in the code) multiplied by the sampling (baud) rate equals the bit rate, the rate at which DCE are designed to operate. Environmental noise can decrease the coding rate so that the difference between bit rate and bandwidth becomes larger. Noise and quantizing error can further in increase errors so that the gap between data rate and bit rate becomes larger.

The bit rate[12] (operational speed of DCE in bits per second) that can be accommodated by any medium is proportional to bandwidth. Therefore, the greater the bit rate, the larger the bandwidth (capacity of a connection) needs to be. Thus, bandwidth typically exceeds the bit rate, which in turn exceeds the data rate.

The third characteristic, data rate (also known as the data signaling speed) measures "the aggregate rate at which data pass a point in the transmission path", typically expressed in bits per second (bps) [GSA, *FED-STD-1037C*, 1996, p. D-4]. Since the data rate is an error-free rate from DCE to DCE, it may be less than the bit rate and always below the bandwidth.

The next characteristic, throughput, can be expressed in two ways. Throughput is an end-to-end (DTE to DTE) measure that can be expressed as "pure throughput", a theoretical capacity (maximum attainable bps), or as an observed "throughput rate" in bps at time t, where bps_t is an actual observation [Sheldon, 1998, p. 972]. Both pure throughput and the throughput rate (also called effective throughput) differ from bandwidth because they are end-to-end measures of the rate at which *user* information (not counting retransmission of errors or transmission of overhead) is processed *and* transmitted. Pure throughput is similar to bandwidth in that it is a capacity, but it is an end-to-end capacity, rather than the capacity of a point-to-point access line or transport link. For example, the compression of voice or data files improves throughput but does not change bandwidth, bit rate, or the next characteristic, data rate.

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[12] The bit rate refers to number of bits in a bit stream per time unit. Bandwidth limits the modulation rate (baud rate) while the coding level n, is limited by the transmission medium, DCE intelligence, and noise. "For n-ary operation, the bit rate equals $\log_2 n$ times the rate in bauds, where n is the number of significant conditions in the signal. "[FCC-STD-1037C, 1996, p. B-11]

Throughput, because it is an end-to-end measure that includes compression but excludes error and overhead, cannot be compared directly to bandwidth, data rate, or bit rate. However, due to compression and in spite of overhead, an observed throughput rate (sometimes called information rate) often is greater than the data rate, bit rate, or even the bandwidth of a particular network segment between the sender and destination. Throughput is the speed measure experienced most by users.

Another QOS characteristic often erroneously confused with bandwidth, delay, is included in throughput. Delay (also called latency) is the actual length of time it takes a bit to travel across a transmission line [Sheldon, 1998, p. 256]. There are three kinds of delay: propagation delay, switching delay, and queuing delay. Propagation delay results from transmission media variables. For example, copper wire has a higher propagation delay than fiber optic cable, while satellite transmissions have higher propagation delays than line-of-sight wireless transmissions do. Propagation and switching delay do not depend on usage levels. However, queuing delay is zero at low use and rises due to congestion bottlenecks that result from high network loads (a systemwide ratio of effective throughput to capacity). Taken together, switching and queuing delay are often called throughput delay since they are variable. The number of hops a signal is switched over a network and the overall network load tend to vary from moment to moment.

The variation in delay, jitter is another way to indicate quality. Jitter refers to the variability of delay measures through time. Low jitter and delay are critical to voice conversations and real-time broadcasting. The highest quality connections are those with a tightly distributed average delay of less than 100ms. Poorer quality connections tend to experience longer delays and greater jitter. For example, satellite transmissions often average near 350ms, with a range from 150ms to 600ms. Pure throughput assumes no jitter and only propagation delay. Since effective throughput is an actual measure, it can reflect both switching and queuing delays. A series of effective throughput observations are needed to measure jitter.

Before proceeding to a computer modem example that clarifies the entries in Table 4-2, it is important to understand the second ingredient of the complex mixture of speed and QOS, the transmission (or signal) technology. First, the word broadband has to be defined. Broadband is used to refer to a range of capacity (or speed). Broadband also is used to describe a particular analog signal transmission technology. Egan characterizes the speed and capacity connotation as follows:

> The term *broadband* is used to describe a high-speed (or high-frequency) transmission signal or channel. It is the functional opposite of *narrowband*, which connotes relatively low speed. While large-scale telephone network trunk lines always operate at broadband speeds, local phone lines connecting households and small businesses to the trunk line are limited to narrowband speeds. . . . The transmission speed of a broadband communications channel is usually measured in megabits per second (Mbps). . . . A low-speed narrowband channel, like today's basic phone line is usually measured in kilobits per second (kbps) . . . [Egan, 1996, p. 6]

The FCC defines broadband as an "elastic" definition that covers bandwidths of 200kbps and over [FCC, October 1999, p. 16-17]. The difference among broadband, narrowband, and wideband is subjective. Broadband networks most frequently are defined as "capable of multi-megabit speeds" [Sheldon, 1998, p. 112; Kumar, 1995, p. 185] or those with capacities greater than 2.048 Mbps [Klessig and Tesink, 1995, p.1]. However, broadband is also taken to mean "any data communications with a rate from 45 to 600 Mbps" [Peebles, Keifer, and Ramos, 1995]. Wideband typically includes capacities greater than the typical (narrowband) analog telephone line of 4kHz but less than broadband capacity [GSA, *FED-STD-1037C*, 1996, pp. W-3-4].

Broadband also describes a specific signal technology where signals themselves (rather than bandwidth) are classified as baseband, broadband, and carrierband. This second use of broadband refers to a type of analog signal transmission technology (typically with a digital source domain) using shared lines. Two other signal transmission technologies are baseband and carrierband.

Broadband signal technology sends multiple analog signals over a range of frequencies (in channels, similar to radio frequencies) over shared conduit. Since noise tends to accumulate in such a scheme, amplifiers are used to regenerate attenuated signals. Because multiple channels are available, many messages may travel at once over a broadband transmission link without automatically exhausting available bandwidth (capacity). Broadband signal technologies distribute modulated data, audio, and video signals over coax, twisted pair, or fiber optic cable. Broadband is the easiest way to deliver a common signal to a large group of locations. Without the addition of electronics that limit eavesdropping, it is possible (with the right knowledge and equipment) to intercept broadband transmissions.

Broadband includes networks that multiplex multiple, independent networks onto channels in a single cable. This may be done through FDM (frequency division multiplexing) where two or more simultaneous and continuous channels are derived by assigning separate parts of the available frequency spectrum (bandwidth) to each channel [GSA, *FED-STD-1037C*, 1996, p. F-17]. Under FDM, signals that are coincident in time are separated in space so that a particular subscriber receives some of the total bandwidth of the connection that serves their location all of the time.

Broadband network technologies allow many networks or channels to coexist on a single cable. Broadband traffic from one network does not interfere with traffic from others because each network uses different radio frequencies to isolate signals by vibrating each signal at a different frequency as it moves over the conduit. Used in this sense, broadband is the opposite of baseband, which separates digital signals by sending them at timed intervals. A broadband subscriber receives analog signals over his own channel on a shared link while a group of baseband subscribers receives common digital signals over a link that is not shared.

Baseband signals are digital (always having digital source domains as well), requiring all of the available bandwidth in a single, shared connection. Broadband signals are analog (having either analog or digital sources) and move over unshared channels on a shared connection [Hill and Associates, p. 303.1.5, 303.1.7]. Carrierband signals are a hybrid of the two.

Baseband signals are used to connect stations on Ethernet LANs and in localized point-to-point or dedicated circuit communication (such as ISDN and HDSL). Baseband signals are transmitted without modulation on a carrier wave, having been digitally imposed on a single base frequency [FitzGerald and Dennis, 1999]. Baseband transmissions use repeaters to regenerate bi-directional attenuated signals. However, even when using repeaters, baseband transmissions are limited in distance compared to broadband. For this reason, baseband signal transmission is frequently used by CPE networks such as LANs.

Any guided medium can be used for baseband[13] signal transmission. The baseband of a broadband signal is the original frequency range before modulation into a more efficient, higher frequency range. Baseband network technologies use a single carrier frequency range (channel) and require all stations attached to the network to participate in every transmission. However, only one digital baseband signal (using the entire capacity of the channel) at a time is permitted. Time Division Multiplexing (TDM) is used to allow users to share connections by taking turns so that all of the bandwidth is used some of the time. Under TDM, a digital signal that is coincident in space is separate in time.

Carrierband is a type of baseband technology where the signal is modulated before transmission over a baseband connection. Standard baseband transmission is un-modulated but is multiplexed to allow multiple transmissions to occupy the path at once. Carrierband technology uses signals that are modulated but not multiplexed so that the entire bandwidth of the channel is available in separate channels (for separate uses) for a single subscriber such as an agribusiness. Individual subscribers send and receive a mix of digital and analog signals over a dedicated (unshared) link that can carry more than one kind of traffic at once. For this reason, carrierband is sometimes called single-channel broadband and is used in HSLN (High-Speed Local Networks) to link "mission critical" processors to each other or processors to peripherals [Maguire, 1997]. Carrierband technology is also used as a digital access level connection, such as in certain DSL services.

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[13] In packetized radio communications, baseband refers to the total frequency band occupied by all the data signals used to modulate a carrier wave.

At the access level, cable TV broadband users share capacity for Internet access with dozens to hundreds of other subscribers over a broadband network. Telephone company digital lines such as DSL and ISDN serve individual subscribers only. Of the three signal technologies, agribusinesses are affected differently by each one. Baseband technologies are commonly part of Ethernet LANs at agribusiness offices. Broadband technologies support services that are offered by Cable TV and wireless firms, typically to small offices and farm residences. Carrierband technologies are sold to agribusinesses by ILECs, ALECs, ISPs, and others but are subject to distance limitations that will be covered in 4.3.

The third and final ingredient in the complex mixture of capacity, speed, and bandwidth is directionality or symmetry. For example, the upload and download bandwidth to bps relationship for a digital source to analog signal conversion depends on both the Nyquist Theorem [1924, 1928] and Shannon's Law [Shannon, 1948]. Furthermore, various sampling, symbolization, and encoding schemes are used by DCE to modulate the signal in order to impose or pack the message content into an electromagnetic pulse or onto a carrier wave. These concepts can introduce directional asymmetries that get specific attention in the next example regarding computer modem communications.

4.2.2 Computer Modems: Bandwidth and QOS

An example concerning the ubiquitous computer modem will further differentiate bandwidth from other QOS metrics. Modems are a particular kind of DCE designed only to work with analog signals and digital sources. Indeed, some say that the modem is a DCE that has reached maturity and is not part of the converged future. However, since modems are broadly representative of DCE (while computers represent DTE) the following example gives a simple lesson in bandwidth, speed, and analog-digital conversion that has broader applicability.

The modem is still a dominant form of connection to the Internet and data networking for households and for many agribusinesses as Figure 4-3 reveals. In 1999, Neilsen NetRatings found that fewer than six percent of U.S. households had Internet access faster than that offered by 56k modems [CyberAtlas, 2000].

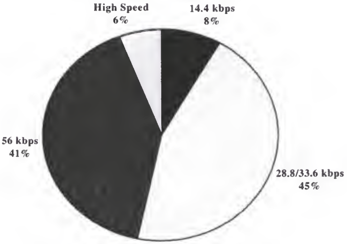

Figure 4-3: Internet Access by Speed, 1999.

Indeed, a majority of households (53%) own modems that are slower than 56 kbps. Additionally, modems that perform at relatively high data rates in urban settings may perform poorly or not at all in rural areas. Thus, the expected obsolescence of the modem will not occur for three to five years for many Florida agribusinesses because of infrastructure problems [FPSC, 1999]. Chapter 5 will provide more details.

The bandwidth of the analog voice channel (telephone line) as shown in Figure 4-4 is 3200Hz wide (3500Hz - 300Hz).[14] This bandwidth was engineered decades ago by AT&T's Bell Labs (when bandwidth was considered to be an extremely scare resource) as the absolute minimum needed to adequately represent the human voice.

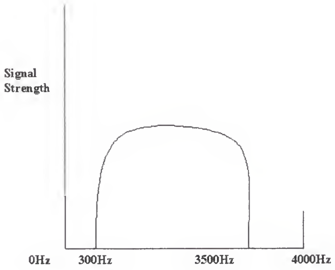

Figure 4-4: Bandwidth of analog telephone line is 3200Hz.

Natural speech is concentrated between 75Hz and 8000Hz, though the human ear has a range of recognition from 75Hz up to 20kHz [EAGLES, 1997]. When the nationwide Bell System was built, filters were placed to block frequencies above 3500Hz from being carried on local lines[15]. A modem attempts to transmit at the highest operational speed (bit rate) that it can given this bandwidth limitation, the equipment it connects with, and the amount of noise present in the line and introduced in the conversion process.

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[14] The typical wire used for analog PSTN connections is capable of a greater bandwidth were it not for special bandpass filters that cut off frequencies above approximately 3500Hz. Twisted-pair wire is capable of much greater bandwidths (700kHz and above). Details are found in 4.3.1, the section on wireline conduit. Note, however, that for many analog lines in rural areas, even the 3200Hz figure cannot be obtained due to line noise and distance-related factors.

Analog-digital conversion (ADC) produces line noise as a byproduct and is, therefore, more sensitive to bandwidth limitations than DAC. It is for this reason that the so-called 56k modems (now generally known as V.90 standard modems) have a higher download than upload speed. Before this asymmetry of speed is covered, it is important to understand the steps in each conversion process.

ADC takes a continuous (in time and amplitude) waveform and converts it to a time-discrete, but amplitude-continuous series of pulses. There are three steps (sampling, quantizing, and coding) in ADC. The first step, sampling, begins the process of converting the waveform into pulses by sampling amplitude values every T microseconds (μs). During sampling, the waveform is scaled into sampling intervals where the sampling frequency, 1/T is also known as the modem's symbol rate.

According to the Nyquist Theorem, the symbol rate (also called the baud rate) used must be less than twice the bandwidth[16]. So, for example, a 3200Hz (cycles per second) signal could be sampled with a frequency of up to 6400 symbols per second. Thus, T the size of a single sampling interval (symbol) is 156.25 μs, which is the minimum constant interval at which the modem samples. In reality, 3200 baud is a commonly sampled rate because 6400 baud is unattainable in practice. Each sample becomes a separate PAM (Pulse Amplitude Modulation) pulse.

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[15] Even though copper wire can allows much wider bandwidths than 3500 Hz, high-speed data transmission had not been imagined when the PSTN was designed. As telephone lines began to be used to carry computer data, Bell scientists pioneered and perfected modems that used existing bandwidth, rather than convert millions of local copper loops to data standards at great cost.

[16] Some authors argue that this should be up to twice the maximum frequency. In the telephone line example, that would be 7000 baud.

The Nyquist Theorem further specifies the levels to be used in the next step of ADC, quantization. Given bandwidth W, then the highest signaling rate C in a *noiseless* channel is given by $C = 2W \log_2 M$, where M is number of coding levels [Maguire, 1997, Module 5, p. 13a]. The number of levels equates to the number of bits per quantization level. In quantizing, digits are assigned to the sampled signals by rounding off (quantizing) the PAM pulses using non-linear companding schemes. When 256 discrete amplitude levels are used to compand the original signal into a quantized sample, eight bits ($\log_2 M$) are necessary. The number of bits per level is $\log_2 M$, so that a 512 level representation contains exactly nine bits, etc.

The third step is coding. In coding, the amplitude levels are mapped into bits that can be understood by digital DTE or DCE. The standard coding rate is eight or nine bits. Given the 3200Hz bandwidth and an eight bit coding scheme (based on a 256 level quantization), the highest bps to be expected under the Nyquist Theorem from a *noiseless* telephone line would be 51.2 kbps.

However, two forms of noise reduce the maximum rate in practice. The first of these, quantizing noise, results from the second step and increases with the number of levels. Hence, it is not possible to add quantizing levels *ad infinitum* or the resulting line noise would cause data rates to fall. Once quantizing noise has been added to the line, it remains there (slowing the rate down) even after digital conversion has been accomplished. This is a particularly limiting case for sending (but not necessarily for receiving) data over a line. To discourage added noise, only the most robust levels can be used to code with so that in practice 256 levels may translate to 128 [3com Corp., 1999, p. 4]. Other forms of noise on lines (a particular problem in rural areas) affect speed in each direction.

Shannon's work on coding led to the development of Shannon's Law which states that the maximum speed C, equals $W \log_2 (1+(S/N))$ bps, where S/N is the un-standardized signal to noise ratio. The signal to noise ratio (SNR) is commonly measured in dB (decibels) where the SNR equals 10 $\log_{10}(S/N)$ dB. The 33.6 kbps upload bit rate (maximum operational speed) advertised for both V.34+ and V.90 modems (over 70 percent of those in use) would require a SNR of 31-32dB for such a speed to be achieved. That SNR is far higher than that typically found, even on lines with a short distance to the serving CO. Thus, noise and the engineered bandwidth in Hz are the chief limitations on the usable capacity of analog line in bps.

To review, the baud rate multiplied by bits/baud (the coding rate) yields the bit rate (operational maximum) of the modem or other DCE. However, high line noise and the presence of noise from quantization itself place limitations on the achievable data rate. When a 28.8 kbps bit rate modem is advertised, it usually is a 3200 baud unit with a signaling (coding) rate of 9bits/baud. Higher speeds are obtained by increasing the baud rate, but bauds above 3429 are rarely obtained in practice due to quantization and/or line noise. Rural telephone lines are notoriously noisy, partially due to the age of the copper lines and also because noise is a function of the distance to the telephone CO.

DAC reverses the steps of ADC. First, the digital bits are modulated at a certain signal speed, governed as before by the Nyquist Theorem. Then, interpolation is used to reconstitute an analog profile of the digital signal pulses. Finally, the digital pulses are decoded into analog waveforms for analog transmission.

Importantly, physical laws preventing speeds greater than 33.6 kbps on upload are less constricting on the download side if certain conditions are met. An important reason is that quantizing noise is not present in DAC. To see this, consider how modems are used to connect with the Internet, a process that is illustrated in Figure 4-5.

Moving from left to right, a modem transmission (upload) follows a path from the customer premises (1) over the access level to the local serving central office (2) of the telephone company. While most calls to modems are local, they commonly are made to ISP numbers in a different telephone exchange with a different telephone CO (3), so the transmission flows over the telephone company's transport level to reach the ISP's CO. Then, the call flows over the ISP's telephone access level to reach a modem bank at the ISP premises (4).

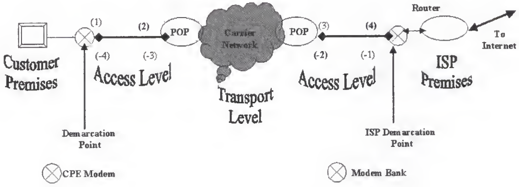

Figure 4-5: Under V.34+ and prior standards, upload and download speeds are restricted to rates under 33.6 kbps.

An upload consists of no fewer than four signal conversions, labeled one through four. A download consists of no fewer than four conversions, labeled negative one through negative four. Of all eight conversions, only three (shown in bold as 2, -2, and -4) are ADC conversions that result in noise that would affect the signal in any direction. The last ADC (-4) occurs once the signals are no longer on the wire, so it does not create quantization noise on any line.

Another example, with a 56 kbps modem, shows the directional limitations of DAC and ADC. When the 56 kbps modem calls over a special digitally equipped telephone line and hooks up with compatible equipment, Shannon's Law and the Nyquist Theorem do not vanish. However, due to the absence of quantizing noise and the removal of ADC on the opposite end, download baud rates of up to 8000 may be negotiated with a seven bit per baud coding rate.[17] The 56 kbps modem process is illustrated in Figure 4-6.

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[17] This coding rate is actually obtained by matching the sending rate to a telephone line codex (codes exchange) that specifies how different binary values sent over the PSTN are converted into specific voltages. Thus, in essence a digital transmission occurs throughout the telephone transport network and over the access network to the recipient. The modem's symbol rate must equal the telephone codex sample rate. Slower baud rates are negotiated automatically if there are intermediate ADCs or if the ISP modems are not on a special line.

Figure 4-6 differs from the V.34+ (Figure 4-5) case in one obvious way. The ISP has purchased a special digital line (a channelized T-1 or an ISDN-PRI T-1) that allows the V.90 equipment at the ISP's premises to interact directly with the telephone company's transport network. Instead of a telco POP (Point of Presence) on the ISP end, a block arrow is drawn to show that the ISP connection is physically on the transport network. In addition, only one conversion (2) is in bold since that is the only ADC conversion that creates quantizing noise that would follow it to the Internet site at which uploading would occur. The download path is free from quantizing noise on the line. Of course, other kinds of line noise would still be present, creating an important reason that 56 kbps Internet access is spotty or even completely absent in many parts of rural Florida.

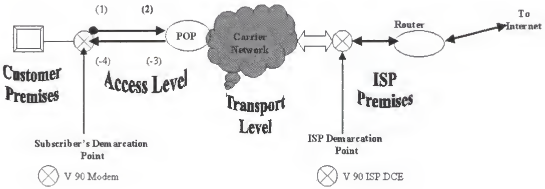

Figure 4-6: V.90 (56k) modems have no quantizing line noise on download, increasing speed.

By now, it should be clear that bandwidth is both a practical and a theoretical measure. Shannon's Law and the Nyquist Theorem provide upper theoretical bounds on channel capacity, while modem advertisements claim a lower theoretical number (an operational bit rate), perhaps more realistic, but still abstract from reality. Line noise and the CPE (modem or other device) on the other side are additional variables. For this reason, modems and other DCE are designed to operate at many different bit rates (operational speeds) because of the variability involved. During the course of a session, modems (like other CPE) must synchronize rates with the bit rate and line conditions on the other end. Hence, during each session, a 56 kbps modem will dynamically adjust (negotiate) upload bit rates of from 300bps to 33.4 kbps (and many levels in between) and download bit rates from 56 kbps down to 300 kbps.

However, the data rate of an actual transfer varies from the advertised bit rate even under low noise conditions because of other sources of variability, the manufacturer, and model. Figure 4-7 shows test results for thirty-one modems *Data Communications* magazine lab tested over a six thousand-foot local loop under controlled conditions ["V.34 Modems: You Get What You Pay For." *Data Communications* magazine, 1995]. Note that the different brands of V.34-Plus (ITU standard) modems did not perform identically under the three tests, although line conditions were the same throughout. V.34 modems are designed to have upload bit rates of up 28.8 kbps and download bit rates of up to 33.6 kbps.

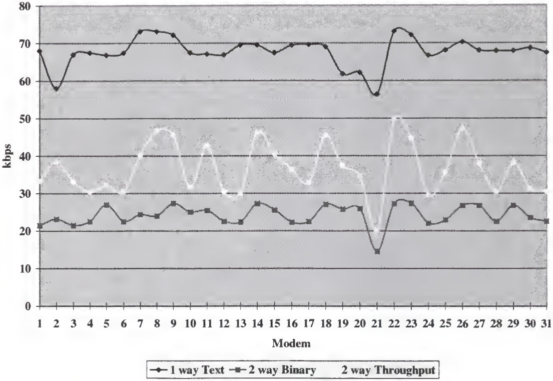

Figure 4-7: Modem Test Variability among V.34 modem brands.

The top line shows the throughput for a (one-way) text download. Due to compression, throughput exceeds the advertised bit rate, the popularly defined "bandwidth" of the telephone line. The middle line of Figure 4-7 shows the two-way average throughput based on binary compressed files. Again, in every case but one, the observed throughput exceeds 28.8 kbps, but that is comparing an end-to-end throughput to the maximum operational data rate (advertised maximum bit rate). Finally, the bottom line shows the average two-way binary file transfer throughput. Notably, while every brand was advertised as a 28.8 kbps modem (able to transmit and receive), the top two had maximum average binary throughputs of 27.4 kbps. When the tests were repeated over different lines (30,000 foot rural local loops), results were as much as sixty percent below Figure 4-7 (when a transfer could occur at all) [*Data Communications*, 1995].

Figure 4-8 shows that the results for the most recent 56k modem standard V.90 indicate somewhat less variability among readings than the 1995 tests of Figure 4-7.

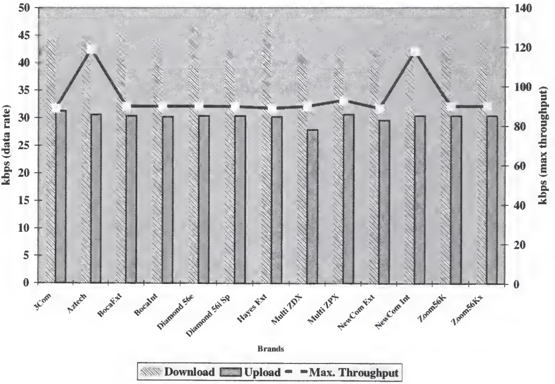

Figure 4-8: Variability among tested V.90 modems.

The one-way (download) text throughput rate (shown on the right y-axis) approached 120kbps on two of the modems shown. While no modem had a data rate of 56 kbps for downloads, the striped columns show that all were above 40kbps. On the upload side, most experienced just under or just over 30kbps data rates as shown by the solid columns.

When modems communicate over networks, the observed data rate and throughput also depend on network QOS variables. Figures 4-9 and 4-10 show how variability in telephone line noise, network congestion, and other factors prevent the advertised "bandwidth" of a modem from being observed in data rates in practice.

Instead of showing laboratory test averages, Figures 4-9 and 4-10 compare incoming data rates (experienced by the author) from the same web site (un-cached in memory) using the same modem and connection. Readings were taken minutes apart, using AnalogX NetStat Live version two software. In Figure 4-9, the average data rate was 13.5 kbps. For Figure 4-10, the average data rate was 17.9 kbps. However, in addition to the fact that in one case the same size file loaded many seconds faster, there were different accelerations in data rates as each transfer proceeded.

The results cannot be explained by any one factor. The differences may be due to an interaction among line noise, other simultaneous requests on the remote web site, the different routes taken by the individual packets of each transfer, ISP network load, and overall Internet congestion.

The computer modem examples have demonstrated several points. First, the theoretical bandwidth of a connection (in this case a telephone line), while often equated with the advertised bit rate (operational speed), differs from the throughput experienced by users and also from the measured data rate of the connection. Furthermore, differences due to manufacturer, line quality, and network conditions affect QOS metrics.

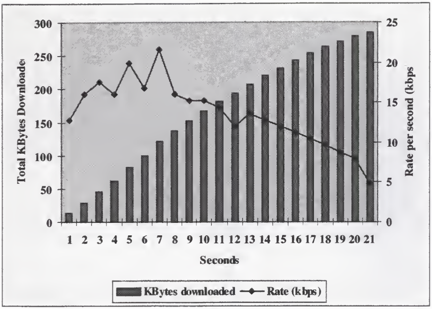

Figure 4-9: 285 KB File Download in 21 seconds on 33 kbps modem.

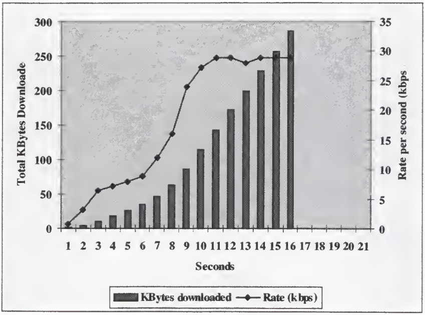

Figure 4-10: Minutes later, the same modem downloads the same file in only 16 seconds.

Until now, the focus has been on QOS metrics that are popularly mistaken for bandwidth. However, QOS metrics must be able to handle the full set of simple point-to-point and internetworked connections of an agribusiness hypercommunications network (that may handle hundreds of simultaneous requests for voice, video, and data). Before more general QOS metrics (including many that are completely unrelated to bandwidth) can be explained, a reference model that is more general than the simple modem example is needed.

4.2.3 QOS Reference Model

At this stage, it is helpful to recall the three network engineering problems and the four objectives of network management from Chapter 3. Any network has combinatorial, probabilistic, and variational problems of engineering. These are sometimes loosely called possibilities, probabilities, and the positive and negative synergies between the two. The way an agribusiness and its hypercommunication vendors define and approach these three engineering problems determines how effectively communications occurs and how efficiently hypercommunications dollars are spent. Additionally, the way the four network objectives are achieved by the carrier influences the efficacy of the agribusiness's connection and the cost efficiencies of the carrier. While the modem example showed that not everything is under either party's control, a QOS reference model will help isolate who controls what.

Instead of two modems, consider a more general agribusiness network such as that in Figure 4-11. Assume that the network is a true hypercommunications network that can carry voice, video, data, fax, e-mail, and Internet traffic. Communications occurs not only among and within offices, but also with customers, employees, and suppliers both nationally and internationally. Notice that the largest node (location) in the fictional agribusiness network depicted is at the headquarters in Loxahatchee, Palm Beach County. Another office is in Homestead, Miami-Dade County. Two smaller locations are in Chuluota, Seminole County and in Southern Highlands County. Suppose that six point-to-point links connect the hypercommunications traffic among offices. Each link could use one or more services and one or more technologies to carry traffic.

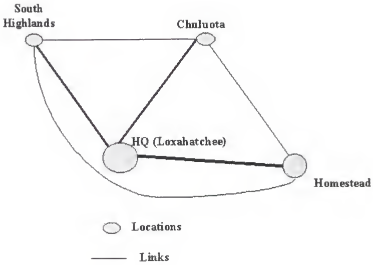

Figure 4-11: Links (connections) and nodes (locations) in an agribusiness network.

The HQ-Homestead, HQ-Chuluota, and HQ-South Highlands links are bold to indicate that a greater amount of traffic flows on these three main links than through the three others. To link any two locations in Figure 4-11, an end-to-end communications pipeline must be able to handle downstream, upstream, and two-way traffic. Users may communicate through computers, telephones, fax machines, or other DTE.

This is further illustrated by summarizing the elements of a single connection between two points as in Figure 4-12. The figure shows various CPE (Customer Premises Equipment) the agribusiness owns in Loxahatchee and in Homestead. On the Loxahatchee end, workstations, storage, and mainframe devices are shown on the uppermost part of the diagram. On the Homestead end, PCs are shown on the upper end of the local network. This configuration between the two locations suggests that traffic will mainly be downstream (from HQ) data traffic as data base information at HQ is accessed by Homestead users. However, data traffic between the two points could just as easily consist of an upstream flow at another part of the day when, for example, sales numbers or other reports are sent to HQ. Two-way traffic could occur between telephones at each location (as shown in the middle part of the local network on either end) or through a mix of computer and telephone traffic (shown in the lower part of the local network on either end). Figure 4-12 shows how varieties of devices (connected in local networks at both locations) allow a mix of traffic to flow between the locations.

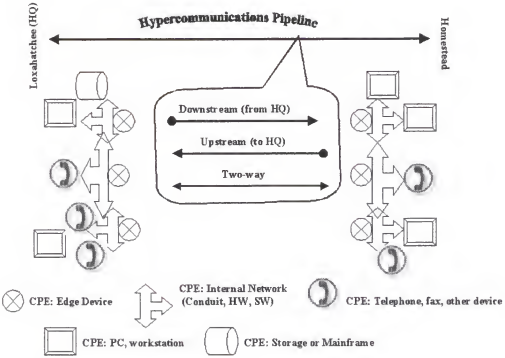
Loxahatchee (HQ)
Hypercommunications Pipeline
Homestead
Downstream (from HQ)
Upstream (to HQ)
Two-way
CPE: Edge Device
CPE: Internal Network (Conduit, HW, SW)
CPE: Telephone, fax, other device
CPE: PC, workstation
CPE: Storage or Mainframe

Figure 4-12: Hypercommunications pipeline includes multi-directional traffic and various CPE.

However, Figure 4-12 is both too general *and* too specific to serve as a general model for use throughout the Chapter. It is too specific because (in addition to the direction of transmission) it mentions numerous user devices such as telephones, faxes, data storage, etc. Figure 4-12 is too general because it appears as though the communications pipeline between Loxahatchee and Homestead can only be a point-to-point link, rather than a more broadly defined network connection.

Figure 4-13 reveals six essential parts of a hypercommunications link between users at HQ and users at any other office without differentiating among services and technologies, or specifying network switching. The six parts are: carrier network (1), carrier POP (2), POP-edge access link (3), edge device (4), inside network (5), and user device or DTE (6).

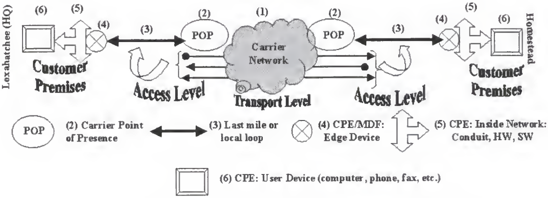

Figure 4-13: Six essential elements of reference model of a hypercommunications link.

It is easiest to work from the inside out of Figure 4-13 to describe the six essential elements. Assume that two-way, upstream, and downstream traffic may be carried between the two points, though each type may be handled differently depending on the service or technology. By formulating the model this way, it is clear that bandwidth is not the only QOS characteristic an agribusiness will be interested in, because bandwidth describes the separate capacities of parts (1), (3), and (5). Each essential element also represents a possible threat to the security and reliability of communications.

The first essential element of a hypercommunications link is the carrier network (1). The carrier network, often called a backbone, is depicted as a cloud because there are many different paths and switching technologies that may be used to transport traffic through the backbone. Usually, the backbone is national or international in scope, carrying traffic for thousands of carrier customers. Bandwidth of backbone networks can range from T-3 (45 Mbps) and upwards over fiber optic cable, satellite, or microwave pathways. While the bandwidth of the carrier's backbone is likely to be more than adequate for the needs of individual customers, congestion can occur if the backbone is oversold or mismanaged by the carrier. Importantly, this central network is also the path over which communications with the outside world occur, though the reference model now is focused on Homestead to Loxahatchee.[18] Carrier networks are covered in more detail in several parts of Chapter 4 including 4.3.4 (data and voice transport), ATM (4.8.3), SONET (4.8.4), and Internet transport (4.9.1). In many cases, carrier networks are already converged networks that handle both voice and data together, though often through parallel structures.

The second essential part of the reference model is the carrier's local POP (Point of Presence). POPs are locations where connections serving a particular area terminate so that traffic can be placed onto the backbone. For example, the POP that serves Homestead might be located in Miami and the POP for Loxahatchee might be located in West Palm Beach. The wireline (or wireless) distance from an agribusiness location to a POP can determines if a particular service can be offered. While each POP is a potential bottleneck, the DCE at a POP typically can handle far more bandwidth than a single customer needs. However, if a POP is oversold or mismanaged by the carrier an agribusiness may not be able to communicate. Carrier POPs are discussed in the context of 4.3 (wireline transmission) and 4.4 (wireless transmission). They appear again as the discussion turns to specific services such as CO technologies that support enhanced telecommunications (4.7.2) and Internet access (4.9.1).

The third essential element is the POP to edge device pipeline (3) that transmits messages between the each local POP and its corresponding agribusiness location. This element is often called the local loop or "the last mile", even though it may be far longer than a mile. Depending on the technology or service, the last mile may be wireline or wireless and be called a link, local loop, circuit, or path. With broadband signaling, the capacity of the connection from the business' edge device to the POP is shared with other customers (like a telephone party line), while with baseband or carrierband signaling it is dedicated to a single user. Depending on which is the case, there may be a potential for congestion. Access conduit is discussed in 4.3.1 and under infrastructure in Chapter 5. Access loops (the physical connection used to support various services) are given further coverage in discussions of the telephone infrastructure (4.3.2) dedicated circuits (4.7.3), and of circuit-switched digital services (4.7.4).

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[18] Loxahatchee could be replaced with New York City or Mexico City without the reference model requiring adjustment.

Fourth, edge devices at each location (4) enable that location to connect to the pipeline. Inside a business' wiring closet, also called the MDF (Main Distribution Frame), an interface is needed to link the carrier's transmission network to the network inside the business. From this point outward, all equipment is CPE (Customer Premises Equipment) because it is physically located at the agribusiness's site and owned or leased by the agribusiness. Edge devices can be interfaces or ports as simple as a telephone jack, or as complex as a T-1 NIU (Network Interface Unit) or CSU (Customer Service Unit). Edge devices must be compatible with the outside carrier equipment and the inside CPE equipment. Edge devices are most important as specific enhanced telecommunications CPE (4.7.1) and circuits (4.7.3 and 4.7.4) are covered. Specialized edge devices are used for private data networking and Internet services as well.

Moving out from the edge device in Figure 4-13, the fifth essential element in the reference model is the inside (local) network at each location. The local network controls how communications travel from the edge device to the user's device as well as how communications between people at that location travel. The local network includes conduit (wiring and cabling), network hardware, and network software. Regardless of the carrying capacity of the external parts of the hypercommunications link, the management, traffic level, and capacity of the local network can prevent an agribusiness from using the bandwidth it pays for or achieving desired data rates. Local network hardware and software must be compatible with the edge devices and with the carrier for reliable service to be expected. A general local hypercommunications network must be distinguished from a local area computer network (LAN) described in 3.5.3 and 3.5.4. However, voice-data consolidation technologies (4.5.4) and call center technologies (4.7.2) can be used along with Internet technologies to create converged networks. Local conduit is discussed in 4.3.1 for the wireline case and in 4.4 and 4.8.5 for wireless cases.

The sixth and last essential element of the QOS reference model is DTE[19]. DTE include telephones, computers, fax machines, and other hardware directly used by people at either end to communicate. DTE must be compatible with local network hardware and software. Each device has its own individual capacity to send and receive communications. User devices on each end must either be compatible or have intermediate CPE to allow interconnection. In some cases, a single malfunctioning user device can slow or completely obstruct communications across the link.

Figure 4-14 ties these six parts together into a general QOS reference model to be used for the rest of Chapter 4. Note the three levels of the reference model: customer premises, access, and transport. The customer premises level is entirely under the control of the agribusiness at each location.

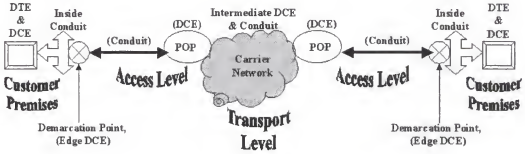

Figure 4-14: General QOS reference model.

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[19] Without loss of generality, the model allows for some user devices that are both DTE and DCE.

The access level is the connection between the agribusiness and the carrier network from the edge device at the agribusiness to the network gateway at the carrier's POP. The transport level (as shown here) is a single carrier's network, but it may be several interconnecting networks owned and managed by separate carriers depending on the distance from receiver to sender.

4.2.4 Fifteen Dimensions of QOS

Now that the reference model is established, the chief QOS dimensions of interest to agribusinesses can be considered. QOS is one of many acronyms in hypercommunications, but is perhaps the most important being one of the twelve essential hypercommunication terms mentioned in Table 1-1.

At first glance, QOS seems to be a simple concept, having to do with measurable degrees of quality customer satisfaction. However, hypercommunication service quality is affected by many issues such as: system reliability and redundancy, customer service and billing, the usefulness and availability of technical support, as well as a number of engineering parameters, software-hardware bugs and idiosyncratic events. QOS concerns apply to all three levels of the reference model (access, transport, and network), but most SLAs cover the transport or transport and access levels only. This is since the carrier cannot be expected to control situations that are on customer premises.

Often, each area has many specific parameters that may or may not be measurable. Indeed, the method of measurement, software package, level of measurement, periodicity, and who will do the measuring are themselves important issues. However, there is not enough space here to delve into the methodology of measurement by dimension.

Table 4-3 introduces fifteen QOS dimensions of greatest importance to agribusinesses. The first six QOS dimensions (bandwidth, bit rate, data rate, throughput, delay, and jitter) have already been introduced in 4.2.1 and were covered briefly in the modem example in 4.2.2.

Table 4-3: Fifteen QOS dimensions

Dimension	Description & Level(s)	Example
1. Bandwidth	Maximum capacity of a link (Access, Transport, & CPE).	3200kHz analog telephone line has up to 56 kbps possible download and a maximum 33.6 kbps upload capacity.
2. Throughput	Transfer speed noticed by users.	Why does it take so long for something to display?
3. Bit Rate	Variable operational speeds of DCE.	Is DCE flexible enough to adapt to many possible speeds?
4. Data Rate	Actual speed.	How fast did a transfer occur?
5. End-to-End Delay	Time it takes for a bit to go from sender to receiver.	1000ms is too long for voice calls, may be fine for e-mail.
6. Jitter	Variation in delay.	Why does the video come and go?
7. Connection Establishment Delay	Time it takes for connection to establish. (Access)	Lengths of time it takes a modem to dial and connect so session can begin.
8. Connection Establishment Failure Probability	Probability that a given connection attempt will not establish. (Access)	Chance that modem cannot obtain connection (busy modem bank, etc.)
9. Network Transit Delay	Time from transport sender to receiver POP. (Transport)	Varies depending on network load, management.
10. Error Rate	Fraction of lost or garbled messages in a sample period.	How often is a sent e-mail not received?
11. Security	Ability of others to intercept or copy messages or gain access to network.	Can messages be intercepted or modified? Can intruders fabricate identities or masquerade as users to gain entrance to system? Is system prone to attack?
12. Priority Classification Availability	Ability of certain kinds of traffic to be sent and received first.	If the company president needs to send an urgent message, can it be bumped ahead of routine traffic?
13. Resilience	Chance that any network level will spontaneously fail.	Can lines be accidentally cut or experience periodic downtime?
14. Environmental Specifications and Safeguards	Likelihood that power failures or weather events will affect communication.	Do carriers have emergency backup generators? Will a thunderstorm or solar flare interrupt quality?
15. Overall Failure Probability	Fraction of time *any* QOS dimension fails to reach standard.	Probability of *at least* one QOS metric being violated.

Sources: Maguire, 1997; Sheldon, 1998; FitzGerald and Dennis, 1999.

The seventh QOS issue, connection establishment delay, refers to the length of time it takes to establish a connection. Like many of the other dimensions, it depends heavily on the user's perception, the specific service, technology, and DCE and DTE. The simplest example is the length of time it takes for a modem to dial and establish a satisfactory connection to the

Internet. It also is applicable to the length of time it takes a telephone call to complete. Some services (such as DSL, cable modem, and T-1 dedicated circuits) are "always-on" and hence, have no connection delay. The eighth QOS category, connection establishment failure probability, refers to the probability of getting a busy signal when a modem dials AOL, for example. In that case, there has been a failure to reach the Internet. For other services, the definition is similar.

The ninth dimension of QOS, network transit delay, refers to the average delay in ms that it takes for a bit to transverse the carrier's network. Unlike end-to-end delay (which is observed), network transit delay is a statistical average that does not count delay resulting from access loop or customer premises conduit and equipment. The carrier may not have control over those other forms of delay, but will have control over transit delay. Hence, most SLAs or carrier statistics that describe delay refer to transit delay (transport level) only. Similarly, most jitter statistics refer to transit jitter, rather than jitter based on end-to-end delay. It can be important as to whether the transit delay and jitter measurements are averages between two points, weighted averages across an entire network, or measured in some other way.

The tenth dimension, error rate, may be a residual measure (on average equal to zero) for some services and an efficiency measure for others. The specific transmission technology and switching method determine the importance of the error rate. In packet switching, the error rate is a background rate that may slow transfers, but switching redundancies and error checking routines are able to recover or correct errors in most cases. Even if the error rate is high across a network such as the Internet, the communication may appear to have been error-free from the user's perspective. Other errors include lost, misdirected, or duplicate e-mails.

Security, the eleventh QOS dimension, is perhaps the most difficult to measure. Security refers to whether others are able (or may be able) to intercept or copy messages or to gain access to network. A security failure can occur at the message, user, or system level. Security failures on any level can result from actions taken within a business, from inside the carrier's network, or from outside.

A security failure on the message level refers to whether outside parties can intercept, modify, or copy messages routinely or intermittently. User level failures refer to whether an outside party can spoof or fabricate the identity of a user and use the communications system, or masquerade as a valid user and gain access that way. A third kind of security failure is a system level failure. System level failures include hacker-vandal attacks and viruses. Hacker attacks begin when outsiders spy on a system to gather confidential information in order to gain later unauthorized systemwide or administrative access to it. Vandals are hackers who maliciously damage systems. Vandals may attempt to crash the system, destroy stored information, or prevent valid users from using the system. Viruses (which do not need to be placed by hackers or vandals) are malicious or annoying software instructions that can do anything from disable a system to cause inconvenience to a single user.

Measuring security failures or violations can be difficult because they can be hidden easily and may not be discovered until after damage has been done. Hardware and software firewalls, security audits, and other methods are used to try to prevent, deter, or catch violations. It is important that a company and the carrier have a security policy that defines violations and prevents vulnerability even to a single point of failure. Vulnerability to a single point of failure means that one person or station (DCE and DTE) could compromise the entire system.

Another QOS dimension is priority classification ability. Priority may be established on a per message, per connection, per user, or a per service basis. The best price for a particular message or service request depends on capacity limitations on how many messages (or how much total traffic) may be sent at once, where, and in what form, and by whom.

The simplest example is the case of a business telephone network with line reduction. Under line reduction, the number of simultaneous incoming and outgoing calls is limited by the number of telephone line equivalents, rather than the number of employees or telephone sets.

Since the purpose of a network is to share resources and lower costs it would defeat the purpose to allow each employee their own telephone line and computer, or to allow every telephone its own exclusive line. However, if all lines are busy, it may be that some users (such as the CEO) need guaranteed placement at the top of the waiting queue or the ability to place a call instantly if the network is full. Voice traffic can be prioritized in several ways.

Prioritization can be more difficult for data traffic or unified data-voice traffic. Certain services and technologies allow the carrier or customer-subscriber to establish priority traffic levels. The highest levels can be carried (for a premium price) at high speeds and superior reliability, leaving other levels to be sent later or get the electronic equivalent of a busy signal. For example, video and voice traffic may require real-time, low delay, and low latency connections that would be a waste of resources for e-mail or routine data transmissions.

Resilience is the thirteenth and possibly most difficult to predict QOS dimension. Resilience refers to the chance that any element of the network will spontaneously fail, causing the complete loss of a particular service(s). Resilience encompasses system reliability. While operational failure probability is concerned with the probability that a particular call or message will fail to achieve certain benchmark standards (such as annoying interference or repeated delay), resilience concerns a total loss of service or outage.

Outages can be complete (network wide) or localized (several connections or customers). Outages can also be random, intermittent, or singular. Singular (one time or episodic), complete outages can result from easily diagnosed causes such as accidental construction cuts of an optical fiber (causing loss of service over an entire carrier network), or they can result from complex equipment failures. As the name suggests, random events occur with no particular frequency and can result in localized or complete interruptions, usually for short periods. Intermittent events occur without apparent regular order, but are often due to complex software-hardware interactions that create hard-to-diagnose sequences of events that trigger partial failure. Intermittent events are more likely to be localized.

Closely related to resilience are environmental specifications and safeguards. Environmental specifications represent the expectations of engineers regarding the operating ranges or time-to-failure of DTE, DCE, and conduit. Environmental specifications include the length of continuous operation, temperature range, humidity range, and the resistance to environmental factors of specific equipment. Environmental standards of electronic equipment also include how well equipment can withstand lightning strikes, electrical spikes or jolts, and other hazards that can cause permanent or temporary failures of components or entire systems. Many wireless transmission technologies require the right atmospheric conditions to operate at peak performance or partial performance losses can occur due to cloud cover or complete interruptions can result from rain, wind, and electrical or solar storms.

Environmental safeguards include systems designed to handle indoor problems such as power outages, emergency hurricane operation, fireproofing, and workplace as well as outdoor environmental concerns. Safeguards may be needed on both the customer premises and carrier network. Some of these include emergency backup generators, surge protection, and redundant connections in case of failure of the main system.

Redundancy refers to how well system backups and contingencies are able to restore benchmark service using secondary or tertiary networks or carriers. The Internet, for example, is a network that was originally designed to remain functional even in case of global thermonuclear war due to built in redundancies. However, it is little consolation to an agribusiness if the Internet is itself still functioning when their ISP's modem bank has broken down, denying them access.

The overall failure probability is the chance that *at least one* of the fourteen other QOS dimensions will fail to attain the standard set for it. Overall failure may be thought of as the chance that anything will go wrong during a particular period. The probability of overall failure is derived using probability theory to obtain estimates of all independent and dependent events associated with each dimension.

4.2.5 QOS in Practice

Now that the fifteen dimensions have been sketched, it is important to understand more about how they apply in practice. A typical agribusiness may have multiple telephone lines, multiple locations, multiple users of the data network, and other variables that affect how QOS is conceived and measured.

Table 4-4 gives an overview of how QOS dimensions can affect agribusinesses in several ways. In the first column, each dimension is categorized in terms of the three core engineering problems and the four technical objectives of network managers from Chapter 3. The following codes are used into indicate the three core engineering problems: combinatorial (C), probabilistic (P), and variational (V). For the four network optimization objectives, the codes used are: sending rate control (SRC), conduit signal modulation rate (SMR), overall network optimization (ONO), and receiving flow control (RFC). Table 4-4 is a general but subjective guide to the relative importance of QOS dimensions.

While pricing may be based on bandwidth (a capacity constraint), users are directly affected by throughput and data rate instead. Indeed, the data rate or bit rates are constraints on the value of a service, along with reliability in general. Throughput is especially important in the pricing of DTE. For example, computer speeds and memory capacities have a direct relationship to what users actually experience as throughput. The bit rate affects the pricing of DCE such as modems and DSU/CSUs. When modems are advertised at 56 kbps, this only means they are capable only of that as a maximum operational rate. For larger agribusinesses with many locations, the network transit delay of the carrier may be important to price and SLA negotiations.

The kinds of traffic most affected by any QOS dimension also involve many details such as message primitive, traffic mixture, and network load. Generally, interactive services such as voice or video are most sensitive to delay and jitter because they are real-time or conversational in nature. Not surprisingly, connection-establishment delay and establishment failure probabilities influence all kinds of traffic carried by services that require the establishment of a connection.

Internet traffic (web pages, FTP, e-mail, Intranet, etc.) and computer network traffic are listed as most affected by security, though most firms have a higher dollar loss from misuse of long distance telephone calls.

Table 4-4: Importance of various QOS dimensions

Dimension	Engineering & network area	Role in pricing	Traffic Most Affected	Impact of violation on user or firm
1. Bandwidth	ONO	High	Data	Theoretical
2. Throughput	ALL	High for DTE	Uncompressed Data	Possibly high
3. Bit Rate	V; SRC, RFC	High for DCE	Data	Indirect
4. Data Rate	ALL	High	Data (video and graphic)	Possibly high
5. End-to-End Delay	C,V; ONO	Low	Interactive (voice, video)	Moderate
6. Jitter	V; ONO	Low	Interactive (voice, video)	Moderate
7. Connection Estab. Delay	P; SRC, RFC	Low	Dial-up Internet, connection-oriented services	High
8. Connection Estab. Failure Probability	P; ONO	Low, causes carrier switching	Dial-up Internet, voice, other connection-oriented services	High
9. Network Transit Delay	C,V; ONO	Moderate	Interactive (voice, video)	Moderate
10. Error Rate	ALL	Low	Data	Usually Low
11. Security	ONO	Low	Internet and data	None to Extreme
12. Priority Classification	C; ONO	If available determines pricing	Voice, Interactive, Mission-critical data	None to Serious
13.Resilience	P; ONO	Low	All	Extreme
14.Environmental Specs. And Safeguards	P; ONO	Low	Mainly to preserve data in emergency	Varies by user
15.Overall Failure Probability	ALL	Low	Varies by event	Varies by event

The impact of problems in each dimension on individual users and firm s are shown in the last column of Table 4-4. Some firms have been destroyed by hacker attacks on un-backed up data, or by revelations of proprietary information and conversations to competitors or the public. Resilience is especially important to the firm, because a violation conveys the complete inability of some or all parts of corporate communications to occur. A business that relies on telephone calls from customers can hardly afford to have calls lost.

Often, when carriers advertise ninety-nine percent or 99.9 percent reliability, they are speaking about resilience. However, with 8.7 thousand hours in a year, a 99.9 percent reliability guarantee allows almost nine hours of total loss in communication to occur before a hypercommunication carrier can be said to have violated that agreement [REA, 1992, p. 1-13]. If those nine hours come during harvest or a heavy season for an agribusiness, (indeed some failures may be most probable at high use levels) they can be devastating. Similarly, if ninety-nine percent reliability is quoted, over 87 hours without service are permitted. Except in rare cases, business losses due to a communications failure are not covered by SLAs, though part of the carrier's bill may be.

There are other QOS dimensions besides those covered. For instance, there are a host of engineering parameters that are set to establish service benchmarks. A carrier has a tradeoff between keeping costs and prices down and ensuring customers a high probability that the system will not be so congested that it is unavailable. The conflict between lowering costs and losing customers is inherent in hypercommunications production. Other engineering benchmarks include intermediate DCE settings that enable interconnection variances below the j.n.d. (just noticeable difference) of consumers or that affect only a proportion of the customer base. Hardware-software bugs and system downtime are frequent possible threats.

Other QOS customer concerns include customer service, custom billing, and technical support. The methods by which customers report problems or get information about system outages (along with how rapidly problems are corrected) are perhaps most important. Billing concerns and the availability, efficacy, and cost of technical support are other QOS concerns. Access by customers to user-friendly technical support is a potential source of carrier revenue either through keeping customers from leaving in frustration or through billing for tech support.

However, technical support is a carrier cost as well because twenty-four-hour, seven-day service is expensive to provide, especially when some customers overuse tech support.

Before concluding the section on QOS in operation, five topics merit brief coverage. First, any measure of speed depends on the acceleration allowed by various protocols based on file size and type. For example, streaming media protocols (used for voice calls, audio, and certain compressed video files) use a fraction of available capacity to transmit communication. Where an entire video or audio program is to be transferred (such as over the Internet), the protocol bit rate prevents the data rate from rising to consume all available bandwidth. Files are sent not as a unit, but as a bit limited stream so the download will occur within a fraction of capacity.

Other kinds of transfers experience limitations on acceleration. Limited acceleration can mean that data rates will never rise to meet capacity. Many businesses have short bursts of traffic with relatively small individual data (file) exchanges. Hence, a firm with a high total traffic volume is punished by limited acceleration if it rarely exchanges multi-megabit or gigabit data files. Limited acceleration means that if large binary data files are transferred, only then does the protocol between sending DCE and receiving DCE allow the bit rate to change to accelerate to the available speed within a channel.

Two figures demonstrate how acceleration works in practice. In the first figure, (Figure 4-15), the data rate accelerates quickly and remains at 1.4 Mbps (1400kbps) during most of the file transfer. In Figure 4-16, the bit rate does not limit the acceleration in data rate, so that the larger the file, the faster the speed becomes. Clearly, it may matter if a particular carrier, CPE, DCE, or service supports one or the other type of acceleration. In some cases, the highest speeds are reserved for the transfer of large files only, rather than for other kinds of communication.

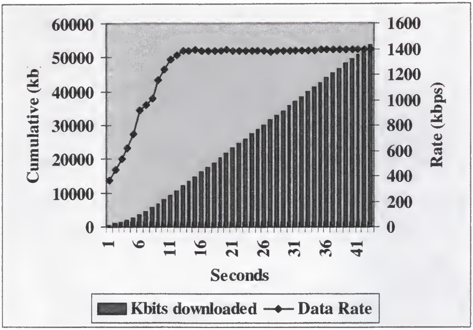

Figure 4-15: Bit rate is fixed so that data rate rises to and holds a certain speed.

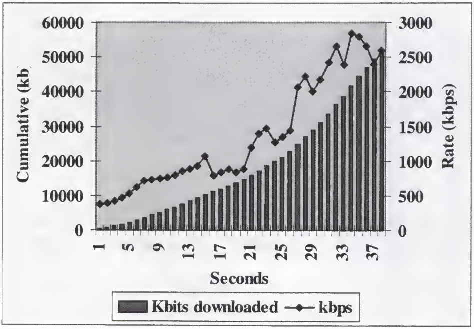

Figure 4-16: Bit rate does not limit acceleration in data rate.

A second operational topic concerns the profile of total traffic through the business day. Rather than measure the speed of a single transfer as in the last two figures, QOS metrics are used to assess whether too much or too little capacity has been purchased by looking at all traffic combined. Many circuits (such as frame relay) use two ways to price: the channel rate and the CIR (Committed Information Rate). The channel rate is a data rate ceiling, while the CIR is a guaranteed data rate floor. To save money, an agribusiness may choose a low CIR, hoping that other customers of the carrier will not congest the circuit to obtain the higher channel rate without paying full price. However, if other customers of the carrier had needed the difference between the channel rate and CIR, the budget-minded agribusiness would have been denied it.

Figure 4-17 shows a capacity of 1.544 Mbps, a common limit encountered with frame relay, T-1, and ISDN-PRI circuits. The maximum, minimum, and average hourly traffic levels of a representative weekday (data rate of all users over a connection) are shown. In this case, the CIR is 256 kbps. The average maximum hourly traffic from or to the agribusiness exceeds the CIR from just after 8 a.m. until 9 p.m. The profile could be the result of a mix of voice (lumpy increments) and data traffic (bursts), but the hourly averages do not show the differences between the two traffic types very well.

The low average hourly traffic line (bottom bold line) shows that even at low usage levels, the CIR is exceeded around 11:00 a.m. and from 16:30 to about 18:30 in the afternoon. The maximum hourly traffic rate is at the capacity from around 16:00 to 17:30, while the average hourly traffic rate has a morning and an afternoon spike at over 400kbps and over 600 kbps, respectively. These results suggest that a greater CIR should be obtained (unless the firm wants to risk connection failures) or that automated traffic must be spaced more widely throughout the day, or both. Network planners often base the channel rate on the maximum busy hour, but the optimal CIR depends on the carrier's other customers.

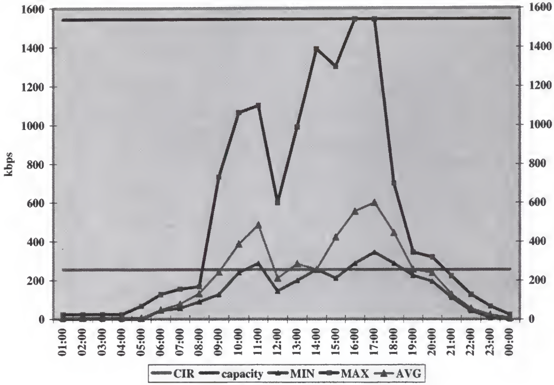

Figure 4-17: Example of hypercommunications traffic in a business.

However, as Figure 4-18 reveals, the average hourly rate masks more dramatic minute-to-minute averages. Figure 4-18 focuses on part of the business' peak time (busy hour) in the late afternoon, from 16:30 to just after 17:00. While the average hourly figures suggest that maximum average needs exceed the 1.544 Mbps capacity for almost two hours per day, the minute-to-minute figures suggest that only about eight minutes does this occur. Indeed, a close examination of the minute data reveals that only eight minute-long periods have *ever* had averages that reached 1.544 Mbps. Some technologies and services allow extra bandwidth to be purchased above the contractual CIR and channel rates. However, a twenty-four hour advance notice may be required for such BOD (Bandwidth on Demand) offerings.

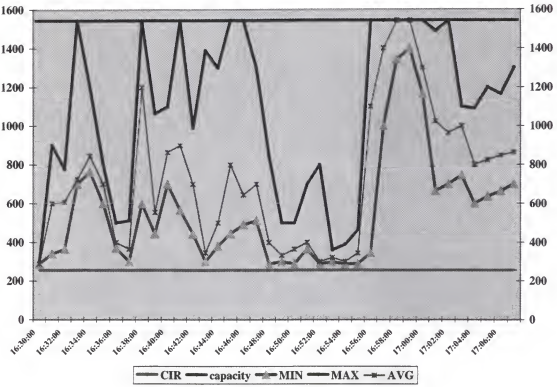

Figure 4-18: Minute-to-Minute Variability may be greater.

As the regular workday closes, traffic dips to low levels. However, just before 17:00 hours, traffic rises again. This gap represents the time of day when the IT department assumes that "normal" operations have decreased enough that automated, routine "end-of-day" data transfer can begin. The problem may be that rather than "needing" more bandwidth, IT personnel schedules and automation routines may need to be more spread apart, since the connection has plenty of extra capacity in late evening, overnight, and early morning hours. Importantly, there can be connection establishment delays due to being over the CIR that can also be involved.

Finally, Figure 4-19 demonstrates delay and jitter. The X-axis depicts the twenty hops an Internet packet takes to travel from Fort Lauderdale, Florida (Plantation) through Atlanta and Sydney, Australia to reach the Australian Government's Antarctica site at Mawson, Antarctica.

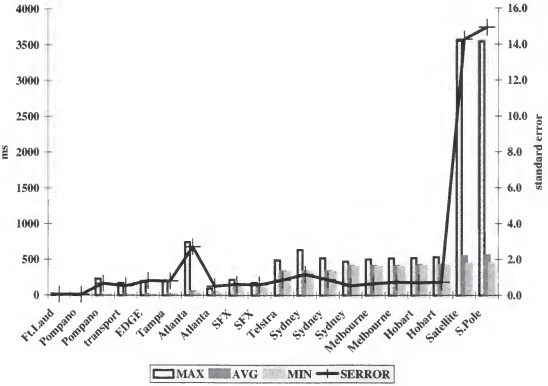

Figure 4-19: Example of Jitter: Variation in Delay, Antarctica from Plantation, FL on 12/16/99.

The bars denote the *independent* maximum, average (mean), and minimum delays (round-trip between Plantation and each intermediate router) in ms using the Ping Plotter ping-trace program from a sample of 1000 cases taken on 12/16/1999. The total delay statistics to Antarctica and back were 3520ms for the maximum, 554ms for the average, and 437ms for the minimum. Jitter can be measured in relative or absolute terms; for Mawson, 330 was the standard deviation with a standard error of 14.9.

Clearly, most agribusinesses do not require connections to Antarctica, but similar results can occur to places as near as Mexico or the Caribbean. However, the jitter example demonstrates three things. First, delay is sensitive to distance. Hence, the more distant a connection, the longer delay will be. Second, delay is sensitive to the service used. Satellite connections especially (used in the hop from SFX, San Francisco, to Australia, and in the hop from Hobart, Tasmania to

Antarctica) introduce delay simply because of the distance from earth to ground and back again. Third, jitter is not inherently sensitive to distance. If the agribusiness had required connection through the first Atlanta hop, jitter would have been greater than if the connection had been in Australia. This is symptomatic of congestion at that hop. Fourth, in many kinds of service (especially Internet-based services), both the carrier and the customer have no control over network routing or the number of hops. Each hop increases the chance that a communication will experience a QOS violation of some kind.

Unlike bandwidth, jitter is a constantly changing measurement that depends on the measurement program used, time of day, general network load, etc. Therefore, different readings would be observed on other days of the week, at various times of day, and with other software measuring programs.

A fourth operational topic concerns the tradeoff between regular file transfers and streaming file transfers as illustrated by Figures 4-20 and 4-21. In Figure 4-20, three kinds of files (text e-mail, web page, and graphic) are shown by their size in KB (KiloBytes) on the left axis, represented by columns. The shaded area shows the fastest length of time in seconds (on the right axis) that a modem (56 kbps) would take to download each file completely.

Simple text e-mails and web (HTML) page content (text and light graphics) take less time since they are smaller files than a graphic file of over 200KB. Each kind of file requires a complete file transfer to become visible at the destination, so the capacity and data rate help determine how soon communication occurs. Both the download time and the data rates vary.

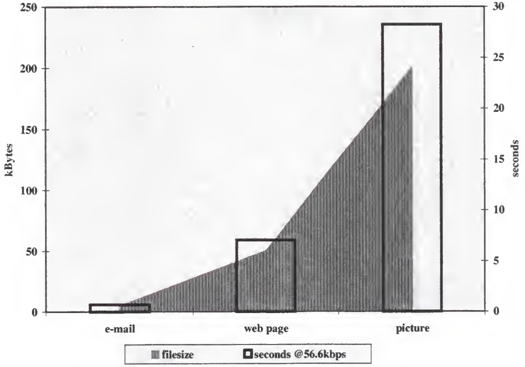

Figure 4-20: Non-streaming file transfers by speed and download length.

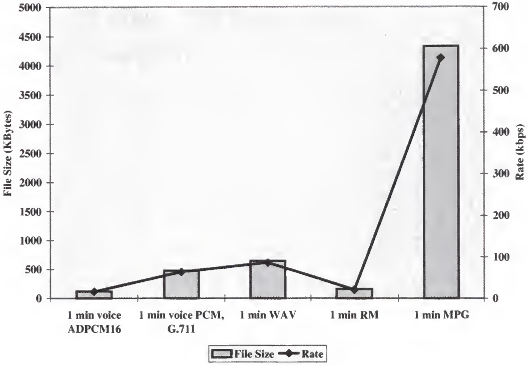

Figure 4-21: Data rate and file size of a one-minute download by protocol.

For real-time or mixed traffic such as streaming media and telephone calls, there is another way to view the situation by allowing the data rate and time to remain fixed. Figure 4-21 shows the capacity needed to download a one minute voice call (using two compression schemes), a one minute streaming audio .WAV file, a one minute .RM (streaming) compressed video, and a one minute .MPG (non-streaming) video. Here the tradeoff is among competing conversion protocols, each of which requires a fixed data rate (on the right axis) over an entire minute to transmit the file size (shown in KB on the left axis).

In one minute, a 577 kbps connection could carry one MPG video, twenty-seven RM video files (21.33 kbps each), six WAV voicemails (86.6 kbps each), nine PCM (G.711) telephone conversations (64 kbps each), or thirty-six ADPCM16 telephone conversations (16 kbps each). These different uses of the same bandwidth are at the center of converged network allocation. Obviously, the video quality in frames per second of the MPG are likely to surpass that of the Real Media RM protocol, just as the PCM G.711 telephone quality will typically surpass that of the ADPCM compressed call.

Recall that throughput refers to the ability of CPE and DTE at both ends to transmit and receive compressed files. The rate referred to above would be an end-to-end throughput rate because coding shortcuts compress messages into fewer bits, enabling faster transport. The savings in speed can be dramatic, but they are due to software rather than increasing the data rate of the communications pipeline. The difference is apparent when two video files (MPG and RM) are compared in Figure 4-21. The RM file designation was developed by Real Audio, so it requires a particular software package to be installed on the each end. The RM video will have fewer frames of video per second than the MPG. However, the RM video stream offers equivalent (or superior) sound and will be seen almost immediately by the user who would have to wait for transmission of the entire MPG file to see it.

The last operational point to cover is symmetry. Figure 4-22 reveals how dramatic the differences between wireline and wireless hypercommunication technologies can be both in terms of advertised upload and download speed among technologies.

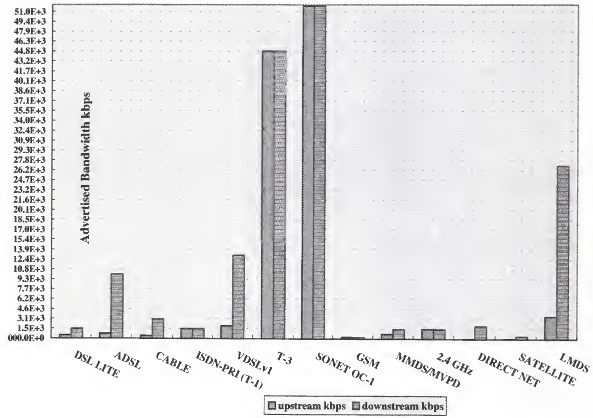

Figure 4-22: Bandwidth symmetry compared among wireline and wireless technologies.

The dashed horizontal grid lines on the y-axis of Figure 4-22[20] are units of 1.544 Mbps (T-1 speeds). From left to right, the technologies delivered through copper conduit include: DSL Lite (1.544 Mbps download, 512 kbps upload), ADSL (10 Mbps, 768 kbps), ISDN-PRI and T-1 (1.544 Mbps, symmetric). Hybrid fiber-coax conduit can deliver VDSL (version 1, 13 Mbps, 2 Mbps) and Cable modems (3 Mbps, 400 kbps). The technologies delivered by fiber optic are T-3

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[20] Sources: Aware.com, Nortel, Paradyne Corp., Schlegel, Nucentrix.com, FCC, PHIcom, and direcPC.

(44.736 Mbps, symmetric) and OC-1 (51.840 Mbps, symmetric), though higher OC (SONET) speeds are available. The remaining technologies shown are wireless. Wireless technologies include mobile GSM (symmetric, 270.8 kbps), MMDS/MDS (1,544 Mbps, 768 kbps), 2.4 GHz (1.544 Mbps, symmetric), direcPC satellite (2 Mbps, 33.4 kbps), other satellite (400 kbps, 33.4 kbps), and LMDS upperband (27 Mbps, 3.5 Mbps).

Figure 4-22 reveals several patterns that will be seen again as Chapter 4 unfolds. First, fiber optic conduit surpasses wireless and other wireline conduit in overall speed and symmetry. Second, many of the faster technologies (wireless and wireline) are asymmetric, offering faster download than upload speeds. Third, none of these numbers can be taken as indications of actual data rates that will be achieved by agribusinesses in practice. With the exception of fiber optic conduit, both wireline and wireless technologies exhibit larger asymmetries, especially as speed increases. Finally, within each technology, dramatic variations from the speed estimates shown can occur because of scant real-world data and differences between carrier sales claims and actual experience [FCC 99-5, 1999].

To conclude, some argue that the trend towards uniform digitization means that bandwidth is becoming a commodity, based on the bit as a unit. However, such a view ignores six important points to agribusiness. First, not all bits are equal because information does not equal data. Furthermore, the transmission of bits (whether data or information) does not ensure communication. Third, no business advantage can be obtained if a particular location has insufficient digital infrastructure capacity so that needed hypercommunication services are not available. Fourth, the transmission of a message from a sender to receiver depends on message primitive, message type, and other factors discussed in Chapter 3.

Fifth, a real-time video cattle auction has different capacity and speed requirements from a text e-mail message, a web page, or a telephone conversation even if each is digital. It is often stated that all a business needs to do is to decide on how much "bandwidth" it "needs", and then hypercommunication needs will have been taken care of. Capacity (along with speed, reliability, latency, and how well the hypercommunication carrier manages the network) is important. However, when bandwidth is used (as it so often is) as a synonym for speed or as a commodity a firm buys in the market, other more specific QOS dimensions have to be controlled for. It can be a costly mistake to compare prices, services, technologies, and carriers based only on bandwidth.

Finally, understanding a set of QOS metrics rather than bandwidth alone can save agribusinesses from unexpected problems and extra costs. The kinds of QOS metrics that a particular agribusiness would agree to in an SLA with a carrier for access and transport differ from the QOS dimensions it would use for its own LAN.

The next three sections cover hypercommunication technologies applicable over all kinds of services. Wireline transmission technologies (4.3) carry hypercommunication signals over several kinds of wire conduit in their journey from sender to receiver. Conduit types include copper wires, cables, and fiber optics. A number of specific enabling technologies (such as DSL, ISDN, and cable broadband) support wireline transmissions. Wireless transmission technologies (4.4) carry hypercommunication signals over airwaves. Wireless transmissions use RF (radio frequencies), microwaves, infrared, and other methods as conduit. Specific enabling technologies support a range of services over wireless as well. Then, section 4.5 covers support services, and facilitation and consolidation technologies.

4.3 Wireline Transmission Technologies

Three technologies are used to transmit hypercommunication signals from sender to receiver. The technologies that enable communication signals to travel over wire, cable, or fiber are known as wireline technologies. Wireless technologies exclusively use unguided media such as radio waves. The third way to transmit signals is over a hybrid system, a combination of wireline and wireless technologies. For example, a long distance telephone call may use microwave transmission over the carrier transport network, but rely on wireline technologies at the access levels at both ends.

The discussion in this section assumes that the communications pipeline is entirely wireline from end to end. During the wireless and facilitating technologies sections (4.4 and 4.5), wireless and hybrid wireline-wireless networks are considered. It is important to realize that most of the hypercommunication services covered in sections 4.6 through 4.9 can be provided through either wireline or wireless technologies.

The discussion in this section covers four topics. Sub-section 4.3.1 discusses guided media or conduit, the wire and cable that carry hypercommunication signals from sender to receiver. The next section (4.3.2) covers the physical plant of the (ILEC) local telco, which already supports an array of services beyond POTS. Then in 4.3.3, the cable TV (cableco) infrastructure and so-called dark fiber plants of electric and other utilities are covered. Large or well-located agribusinesses may be able to connect directly to the backbone and transport networks (4.3.4), bypassing telco and cableco access levels entirely.

The physical plant or infrastructure includes conduit, junction boxes, manholes, MDFs, and various kinds of DCE including routers and switches. In a converging market, wireline distribution technologies can carry services beyond those offered by traditional monopolies associated with each infrastructure. For example, an urban or suburban agribusiness could easily use the telco "plant" to carry its data and Internet traffic, the cableco plant to carry telephone, or even the electric utility's infrastructure to carry data traffic. Convergence means that every infrastructure will be able to carry every kind of traffic. In all cases, the agribusiness needs to buy or lease DCE, DTE, and conduit.

4.3.1 Conduit

The skeleton of any wireline communications network is conduit. There are three chief kinds of conduit in common use: two-wire (and four-wire) twisted pair copper loops, coaxial cable, and fiber optic cable. Within each type, there is considerable variability in the speed, capacity, and distance supported by various sub-categories. While many QOS metrics are constrained by physical properties of conduit, new technologies are constantly being introduced that can squeeze faster speeds from existing conduit. Additionally, compression technologies and new conduit categories can extend distance, throughput, bit rates, and data rates.

Figure 4-23 repeats the QOS reference model, showing again the three parts of the communication path between two points to reveal the need for specialized wireline technologies and conduit.

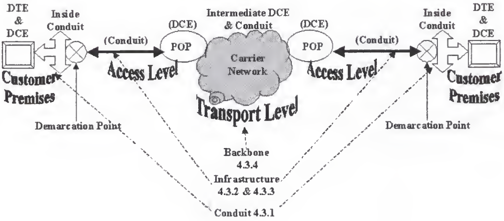

Figure 4-23: Wireline section coverage by reference model.

Conduit is the only topic here in section 4.3 that bridges all three levels shown in Figure 4-23. First, the customer premises side of the demarcation point has conduit for the inside or local network at the agribusiness. Second, there is conduit in the access level between the agribusiness and the carrier's POP. Third, there is conduit within the transport level (carrier network).

Since specialized conduit exists at each level, it is easy to confused the copper twisted pair cable used in the telephone access network with the copper twisted pair used as customer premise conduit for computer LANs. Furthermore, no level uses a single kind of conduit alone. For example, the transport level may transverse thousands of miles and several carrier networks in the case of long distance telephony. When a carrier other than the ILEC provides a communications path at the transport level, there is a handoff point from the ILEC (which provides the access loop) to the other carrier (such as an ALEC, ISP, or IXC). The handoff point may be at the local POP or inside the ILEC's transport network. Hence, the transport level can consist of more than one carrier's transport network. The Internet backbone, for example, is a network of transport networks.

The first way wireline transmission is accomplished is by insulated copper conduit, either two-wire twisted pair or four-wire twisted pair (Quad). Both are used in the access layer to traverse the last mile between a subscriber's premises and the location where the carrier's network begins, the POP in Figure 4-23. Many wireline services in addition to POTS can use the copper wire plant built by the ILEC to connect to a local wire center, CO, or POP owned by the ILEC.

Competitors of ILECs such as (ALECs) use the ILEC's local loop to transmit communications to their own POP switch or to a POP co-located at the ILEC's CO. Long-distance carriers (IXCs) also use the ILEC's local loop so customers can access IXC networks. Facilities-based ALECs and IXCs use their own transport network for PSTN traffic. Non-facilities based ALECs and IXCs lease transport networks from other firms. For non-telephony services such as Internet and private data networking, the ILEC's local copper loop connects to a POP owned by an ISP (or other carrier) or to a server co-located at the ILEC's CO. Internet and data traffic normally travel over a transport network that is separate from the PSTN.

Twisted pair may carry analog or digital signals. The bandwidth (capacity) of twisted pair depends on length (distance traveled), category, and wire gauge. The gauge of the wire refers to its thickness, with a 24-26 gauge being the typical used for telephone.[21] Ordinary telephone twisted pair can achieve a maximum data rate of four Mbps for a distance of up to ten kilometers (6.2 miles). Category 5 or 6 UTP (Unshielded Twisted Pair) copper used for LANs on customer premises can achieve much higher data rates, but for considerably shorter distances. Wiring standards are defined for the six categories of twisted pair[22] in Table 4-5.

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[21] 24 AWG (American Wire Gauge) wire is 1/24" in diameter and 26 AWG wire is 1/26" in diameter. [Paradyne, 1997, p.12]

Table 4-5: Copper twisted-pair wire categories.

Category	Uses	Bandwidth (data rate)	Distance	Cost
Category 1 (1 pair)	Pre-1983 installed telephony (access)	3.1 Hz (28 kbps)	5 miles	NA
Category 2 UTP (2 pair)	Telephony (access), legacy data (CPE)	2 MHz (to 4 Mbps)	6.2 miles	$0.11/ft. (bulk)
Category 3 UTP (4 pair)	Analog or digital telephony CPE, Ethernet (to 10 Mbps), Token Ring (to 16 Mbps)	To 16 MHz (to 45 Mbps)	1000 ft. run	$0.11/foot (bulk), $0.21/ft. (plenum)
Category 5 UTP	Standard for Ethernet horizontal (to desktop), ATM	To 100 MHz, (to 155 Mbps)	300 ft. run, 800 ft. total	$0.12-$0.17/ft. (bulk), $0.32/ft. (plenum)
Enhanced Category 5 UTP	Higher quality Cat 5, minimizes crosstalk	200-350 MHz (to 200 Mbps)	1000 ft.	$0.17/ft. (bulk), $0.40/ft. (plenum)
Category 6 UTP	Gigabit Ethernet	350 MHz and up (To 1 Gbps)	1000 ft.	$0.15-$0.22 ft. (bulk), $0.35/ft. (plenum)
STP	Token Ring	4-16 Mbps	1000 ft.	$0.27/ft. (bulk)

Sources: Tower, 1999, Sheldon, 1998.

In reading Table 4-5, realize that each row in the table supports the features of the category above it. Over sixty percent of U.S. buildings have Category 5 as their local conduit. Category 2 is typically found on the access level only, while categories 3 and above are strictly for use on customer premises.

Two-wire and four-wire twisted pair (quad) may differ in several additional ways. Quad telephony wiring is often thought of as the extra wire pair that accompanies the regular telephone two wire pair going into homes so that an additional line may be added. Quad twisted wire is also used for long analog loop distances due to its easy use with amplifiers, on customer premises, or in the digital access loops to support high-speed services such as HDSL (High Data rate DSL)

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[22] These are discussed on the CPE level in Chapter 3.

[Paradyne, 1999, p. 23; Schlegel, 1999]. Copper wire is used for both baseband and carrierband transmission technologies on customer premises and in the access level.

Coaxial cable is another kind of wireline conduit. A hollow outer cylindrical conductor of solid copper encloses a single inner wire conductor. The cable can be between one and one-half inch in diameter. Coaxial cable (coax, for short) has a bandwidth of up to one GHz that can theoretically support data rates of up to 400-500 Mbps over longer distances than twisted pair.

At one time, coax (able to support from 600 to 10,800 voice circuits per cable) was regularly used in the telephone transport level. Now, while coax is still used in the telephone transport network leading out of rural areas, it is most likely to be found on customer premises. Coax is used intensively at the access level by cable TV carriers to carry video, voice, and data. Coaxial cable is used to transmit data, voice, and video using baseband and broadband transmission technologies. Coax can transmit either digital or analog signals. Coaxial cable is less likely to have cross talk or interference than twisted pair. Coax can be used at higher frequencies and data rates than twisted pair can as well. For example, the L5 CCITT coax specification calls for an analog cable (with operating frequency of 3.12 to 60.6 MHz) capable of carrying 10,800 voice channels. However, the T-4 digital designation can carry 4,032 voice channels with a data rate of 274.176 Mbps [Maguire, 1997, module 5, p. 27].

To transmit digital signals effectively over longer distances with coax, repeaters are needed. A data rate of up to 800 Mbps can be achieved with repeaters spaced every five thousand feet. The three main types of coaxial cable are RG-58 A/U (Thinnet, stranded wire core), RG-58/U (Thinnet, solid wire core), RG-59 (Thicknet, cable TV and broadband), and RG-62 (ArcNet). CATV cable can be further categorized by format: subsplit, midsplit, highsplit, or dual. Each of these four formats is 75 Ohm coax with 75 Ohm terminators. Bandwidth for subsplit ranges from 5-30 MHz (inbound) and 54 to 500 MHz outbound up to more recently deployed dual with a 40 to 400 MHz inbound and 40 to 400 MHz outbound bandwidth [Maguire, 1997, module 6].

Cable types cannot be mixed on a network without intermediate devices. Through the use of "resistance to ground", coaxial cable is often called a balanced transmission line because the conductors have equal resistance per unit length and equal capacitance and inductance between each conductor and ground. Additional advantages of coax are that it is flexible and easy to install and provides better resistance to electronic interference than twisted pair. Disadvantages include the cost (more expensive than UTP), the difficulty in changing configurations, and the requirement for repeaters to cover longer distances. Thinnet is generally not suitable for use between buildings. Both coax and copper twisted pair can be tapped, presenting something of a security risk [Tower, 1999].

Fiber optic cable offers very high bandwidth, measured in THz (trillions of Hertz), so that the entire usable RF spectrum can be carried on a single strand. Fiber optic cable is predominately used at the transport level where efficient, bulk transmission is a necessity, though hybrid fiber-coax (HFC) is now in the access level in some cases. The maximum length of a fiber optic segment can range from around twenty miles to several hundred miles before a repeater is needed.

Fiber optic cable and the necessary transmitters and receivers are costly. Six-fiber cables cost (in materials alone) at least $5,800 for two miles and $29 thousand for ten miles, while 48-fiber cables cost $16,360 for two miles and $81,840 for ten miles. The materials cost of fiber optic cable is small compared to installation, labor, and the price of fiber optic transmitters and receivers needed to establish communications [IEC, 1999, p. 6]. Multimode fiber used for data communications costs $0.70 per foot, while single mode fiber (used more in video) costs from $2.80 per foot and up [Tower, 1999].

Optical fiber is a thin, typically flexible conduit (also called waveguide) that conducts light rays using silicon glass or plastic fibers through its core. These fibers are clad with special glass or plastic coatings (cladding) with a layered plastic jacket designed to prevent moisture, crushing, or other hazards from breaking the internal fibers. Strands pass signals in only one direction so separate strands are needed for sending and receiving. Messages are converted into optical signals (photons), which are transmitted (flashed) down the optical fiber by a laser or light-emitting diode. A photo-detector on the other end receives the optical signals whereupon they are converted back into standard digital signals. Table 4-6 shows the three general types of optical fiber.

Table 4-6: General types of optical fiber.

Type	Diameter Core/Cladding (Micrometers)	NA	Attenuation (dB/km)	Distance-Bandwidth product (MHz-km)
Short Distance, Multimode step-index	100/200	0.3	5-10	20-200
Long Distance Graded Index multimode	50/125	0.2	1-5	500-1500
Single Mode	6/125	0.03	<1	>1000

Source: CORD, 1974, 2000, Tower, 1999.

Some kinds of multimode fiber (such as step index) are used for shorter, local installations, while graded index fiber is used for longer distances. Multimode fiber has reflective walls that move light pulses through the fiber to the receiver, allowing the refraction of multiple light paths through the fiber center core. In addition to the 100/200 core-cladding sizes, multi-mode is available in 62.5/125 (EIA/TIA standard), 100/140, 85/125, and 50/125. The 50/125 multimode is a long distance graded index fiber with the greatest carrying capacity. However, it requires extreme precision during splicing.

NA (Numerical Aperture) is a measure of the light gathering power of fiber. NA refers to an imaginary cone that defines the acceptance region of the core or the ability to accept and carry rays of light. With single mode fiber, light is guided down the center of a narrow core much more precisely (over a single mode or path), with a tighter NA than multimode. Single mode fiber needs precision when connecting and splicing it to the laser source, but the power requirement is lower. Single mode is far more costly than multimode fiber, but is able to support next generation technologies such as SONET OC-12 (622 Mbps) data rates because of the absence of multimodal dispersion.

Signals on fiber-optic cable experience considerably less attenuation while immune to capacitance and electrical interference. For these reasons, fiber greatly surpasses the transmission distances of both twisted pair and coax. In addition, fiber-optic cable is more secure than copper cable since any external tap is easily detected by a reduction in signal strength. The final column in Table 4-6 is " . . . the distance-bandwidth product, expressed in MHz-km. This gives the product of the maximum data-transmission rate and the maximum distance between repeaters. It is a common figure of merit used to characterize system performance." [CORD, 2000, Module 8]

Advantages of fiber optic cable include transmission rates of 100 Mbps and up over strands hundreds of miles long, better security, and the lack of electrical interference. Furthermore, fiber optic is considered to be more secure than coax or twisted pair. Disadvantages of fiber include the high cost, the difficulty in working with it, and need for specialized tools and training. Fiber can be hard to work with because it is inflexible and bulky. Fiber is often used in backbones between buildings and in Token Ring networks. Telcos have deployed it widely to replace coax long-distance trunk lines in the transport level. Cablecos that offer digital TV, high-speed Internet, and telephony use fiber connections to individual homes and businesses.

DWDM (Dense Wave Division Multiplexing) has exponentially expanded the capacity of existing fiber optic networks. Under DWDM, multiple signals are multiplexed onto separate wavelengths of light carried by a single fiber strand. According to the communications research firm Telegeography[23], all 81.8 billion minutes (over 56 million days worth) of traffic that was carried on the world's telephone network during 1997 could be sent over a single fiber of the latest-generation fiber optic systems in just eleven days. DWDM can carry up to 25 Tbps (tera, trillion bps).

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[23] "Leaders of the Bandwidth," *Red Herring*, November 1999.

Guided media such as copper wire, coaxial cable, and fiber optics have five chief physical properties that can vary the capacity and quality of hypercommunications, especially in rural areas where wire distances are longer. These properties have been alluded to in context, but it may help to describe them further. In every case, fiber optic cable is superior to coax, which is superior to twisted pair.

The first physical property of wire is attenuation, a loss of signal strength or amplitude that occurs over distance as the signal passes down conduit. According to Sheldon "attenuation is measured in dB (decibels) of signal loss. For every 3dB of signal loss, a signal loses 50 percent of its remaining strength." [Sheldon, 1998, p. 995] At higher frequencies, skin effect, inductance, and capacitance cause attenuation to increase [RW Cabling Sciences, 1998]. Repeaters (digital), amplifiers (analog), and other devices are used to extend the distance limits caused by attenuation.

The second physical property of guided media is capacitance. Capacitance is a measure of stored electrical charge in a cable or wire. Stored charges can distort transmissions by changing the shape of the signal. Too thick or too closely bundled wires are especially likely to contribute to capacitance. At higher frequencies, capacitance becomes a greater problem, leading to increased attenuation.

The third physical property of guided media is impedance or delay distortion. The impedance value of wire or cable can be measured in ohms. Impedance is a combination of the inductance, electrical resistance, and capacitance of a transmission line. Impedance arises because the propagation velocity is a function of frequency so that only part of the signal arrives at one time at the receiver and part at another time. Impedance is a measure of the opposition offered by the wire to the flow of the carrier wave. Shortening the transmission path distance or lowering the frequency can help reduce impedance. Impedance can be a major problem for digital systems (inter-symbol interference). Abrupt changes in impedance (called discontinuities) distort signals, causing network problems [RW Cable Science, 1998].

The fourth physical property of guided media is noise, an unwanted signal that interferes with, changes, or blocks the transmission and reception of a desired signal. Several kinds of noise can occur, both predictable and unpredictable. Thermal noise occurs across all frequencies. Intermodulation noise happens when frequencies and multiples of their harmonics interfere with the original signal frequency. Impulse (or background) noises include random noises, often of large strength, such as lightning, motors, and elevators. Impulse noise is also generated by adjacent lines and transmitters. Ambient noise can be caused by motors, electronic equipment, nearby radio equipment, electric lines, and fluorescent lights.

The fifth physical property of guided media is inductance or cross talk. Cross talk is a special form of interference (noise) that results from an electromagnetic coupling of one wire with another [REA, 1751-H, 403, p. 9-4]. The number of twists made in a length of wire is one way copper can limit cross talk. Cross talk may be at the near end such as NEXT (Near End Cross Talk) or at a far end such as FEXT (Far End Cross Talk). Shielded twisted pair (STP) is a special kind of copper wire (with aluminum wraps or a copper braided jacket around insulated conductors) used especially in business settings to reduce inductance and crosstalk. It can support transmission over greater distances than unshielded twisted pair can.

Table 4-7 summarizes the general upper theoretical limits of the most frequently used forms of wireline conduit. However, because there are many variants within each of the three main types the table is only a rough guide.

Fiber optic cable is the overwhelming favorite for the transport level and is increasingly used in the access level. Copper twisted pair is still the most frequently used conduit at the access level because of the high cost of replacing the enormous amount that is already present in the telephone infrastructure. Coaxial cable predominates at the customer premise level for data connections, with copper still occupying the leading position for telephone connections. Hybrid fiber-coax and fiber-copper access conduit combinations are becoming increasingly common as telephone companies and cable TV companies compete to modernize their infrastructures so as to offer voice, data, video, Internet, and other high-speed services to residences and small businesses.

Table 4-7: Summary of wireline conduit capacity, cost, and distance.

Type	Distance Limit	Bandwidth	Data Rate	Cost
Analog telephone Twisted Pair	30-50,000 feet	0–3.3 Hz, with guardbands	To 56 kbps	$0.11/ft.
Category 3 UTP	6.2 miles (access, w repeaters), 1000 feet on premises	0-1 MHz (10^6)	up to 45 Mbps	$0.11/ft.
UTP Category 5	800 feet	0-100 MHz (10^7)	Up to 155 Mbps	$0.12-$0.17/ft.
UTP Category 6	1000 feet	0-350 MHz	1 Gbps	$0.15-$0.22/ft.
Coaxial Cable	Miles	0-1 GHz (10^9)	Hundreds of Mbps	$0.33-$1.13/ft.
Fiber Optic Cable	Hundreds of Miles	0-1 THz (10^{12})	hundreds of Gbps	$0.70-$2.80/ft.

4.3.2 The Telephone Infrastructure

The telephone plant has evolved from an analog, all-copper conduit system designed to carry voice calls alone to a mixture of digital and analog circuits that carries voice and data traffic over a mix copper wire and fiber optic cable. In the telephone plant, copper conduit is usually found on customer premises and over the access level (especially the local loop). According to Paradyne Corporation, over 95 percent of local access loops are two-wire twisted wire supporting POTS [Paradyne, 1999, p. 5]. Multi-strand cables of up to 500 twisted-wire pairs may be used over the last hop of the access level. The transport level relies almost exclusively on fiber optic backbones and microwave or satellite paths.

AT&T and other telephone company research programs have been behind the invention (and in many cases, the development) of technologies that have made high-speed wireline hypercommunications possible. Digitization resulted in reduced bulk transport costs and better call processing in spite of the fact that digital voice requires more bandwidth than analog does.

An important rule-of-thumb that prevailed for years (in the transport network), was that 8kHz was required to carry a 56-64 kbps digitized voice signal using PCM on the same copper conduit that occupied 3.1 kHz on analog lines. New speech codecs are available to reduce the bandwidth requirements, but there is a tradeoff in quality.

While the evolution from analog to digital and from copper to fiber have changed the telephone transport network, the local loop (the access network) typically relies on copper and has remained analog. The copper access network has been designed to handle voice telephone traffic in a narrow bandwidth of approximately 3Hz (see Figure 4-5). As was discussed in the V.90 modem example, under the best conditions (low line noise and subscriber-CO distance of fewer than 30,000 feet), the highest possible data rates would be 33.6 kbps upstream and 56 kbps downstream. In rural areas, (and indeed in many urban and suburban ones), line conditions may not reach anywhere near these capacities.

However, copper wire itself is not responsible for the lack of capacity. Copper wires can be used to extend high speed hypercommunication services thanks to several technologies such as ISDN, DSL, and DS1 (T-1). To understand how these technologies work, it is necessary to examine how the telephone transport and access networks have evolved.

Traditionally, the local exchange was the foundation of a five level hierarchy of exchanges built when AT&T was the national telephone monopoly. While large areas of Florida were served by independent telephone companies before the AT&T breakup the AT&T exchange hierarchy was followed (even by the independents) as the PSTN evolved from analog to digital and copper to fiber. Table 4-8 shows the exchange classes in the hierarchy.

The first stage in the dual evolution from analog to digital and copper to fiber came at the Class 1 level (farthest from subscribers), when traffic between regional centers was digitized and sent over high-speed microwave or satellite links. Then, traffic from sectional to regional centers became digitized and sent over microwave links. By the early 1980's, primary to sectional center traffic was also digitized and sent over microwave links, a technological change that allowed firms such as MCI and Sprint to begin limited competition with AT&T for long-distance customers. Regional centers began to be equipped with fiber optics in the mid-to-late 1980's so they could connect with other regional and sectional centers at record speed [Oslin, 1992]. Coaxial cable, specially conditioned copper loops and, finally, fiber optic cables were used to connect class four and class five exchange offices.

Table 4-8: Telephone transport hierarchy: AT&T exchange classes.

Exchange Class	Description	Serving Areas	Function (CLLI)
Class 1	Regional Center	Atlanta center served southeast USA	Switch National and International calls for IXCs
Class 2	Sectional Center	Entire LATA or market area, e.g. Orlando	Switch inter-LATA calls, intrastate calls for IXCs
Class 3	Primary Center	Area code or EAEA. Place where call moves from independent to Bell System, e.g. Eau Gallie.	Switching Center, SAP or EAEA intra-LATA calls from LECS to IXCs
Class 4	Toll Center / Rate Center	Urban-suburban local calling area or group of rural COs.	Main office serving group of LEC COs, local inter-exchange calls
Class 5	End Office/ CO	Rural local calling area or urban NXX group, e.g. Kenansville.	Physical location where local loop begins, local intra-exchange calls

After the breakup of AT&T, developments in fiber optic and digital transmission technologies allowed telephone companies to operate digital transport networks. However, in many rural areas, copper or coax transport conduit was still used, even while bulk traffic became digital rather than remaining analog. This was because the fixed cost of upgrading copper transport to fiber could not be offset by revenues in low-density areas. In many areas of Florida, per subscriber revenues in sparsely settled areas are lower than in urban areas, although costs of service are higher.

However, in suburban areas and the urban fringes, it became generally apparent that not all of the local loop would have to be changed from copper to fiber in order to support certain telco carrier services. One option that has been widely deployed by BellSouth in Florida is the

DLC (Digital Loop Carrier) which multiplexes many circuits onto a few copper wires or a fiber optic strand. For example, the Northern Telecom Remote Switching Center-S can consolidate the traffic of over 10,000 telephone lines onto 16 T-1 trunks (48 wires) [Nortel, 1998, p. 69]. This allows many traditional CO services to be delivered by telephone companies up to 150 miles away from the subscriber.

By using Remote Access Vehicles (RAVs) and DLCs (Digital Loop Carriers), enhanced telephony services are more available in rural Florida. RAVs are intermediate access level nodes where copper runs to the subscriber and signals are aggregated and back-hauled via fiber optic or enhanced copper from the RAV to the carrier POP. RAVs are especially important in rural areas where the distance from the subscriber to carrier facility exceeds 18,000 feet [Nortel, *Telephony 101*, 1998, p. 68].

Hence, as Figure 4-24 reveals even though most ILEC COs cover a small geographic fraction of the state's total area, ILECs or competing ALECs could offer most central office traditional telephone services virtually anywhere in the state. However, the same is not true for most kinds of high-speed access provided through the telephone plant using the resulting copper-fiber mix.

In the figure, dots represent an 18,000-foot radius surrounding the location of all COs and wire centers RAVs in Florida as of July 1999. New digital loop technologies allow COs to be served from facilities located hundreds of miles away, meaning that competing traditional telephone service providers would not need to build costly plants all across the state.

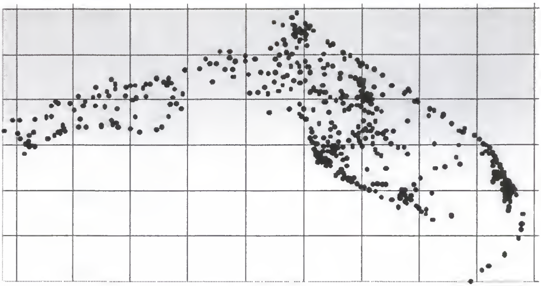

Figure 4-24: CO locations in Florida with 18,000 foot distance circle.

However, RAVs (also called DLCs or Digital Loop Carriers) and new switch technologies do not change the basic physical laws governing copper wire regarding enhanced high-speed services (such as data and Internet). The extension of high-speed services requires subscribers be within 18,000 to 35,000 feet of the serving central office or RAV. Many telephone subscribers are outside the 18,000-foot limit[24]. While many RAVs were deployed to provide enhancements to traditional telephone service, only a fraction can be modified to bring high-speed services closer to subscribers. Figure 4-25 focuses on how RAVs represent a recent evolutionary stage in telephone network access.

In Figure 4-25, thicker lines represent trunks and feeder fiber optic cables with multi-gigabit capacities among the central offices. The figure compares CO-1 (non-RAV) at the top with CO-2 (with RAV) shown on the bottom. Features of comparison are numbered. In the CO-1 case, the office building (1) is able to have high-speed T-1 services, as is the farm labeled (2). However, farms labeled (3) are too distant to receive high-speed service. The residences near CO-1 cannot get high-speed services because of limitations in the ratio of high-speed to narrowband copper.

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[24] In the BellSouth service area, the average loop length (by customers) is 16,973 feet. However, the average loop length (of location clusters) is 24,821 feet. [FCC, 2000]

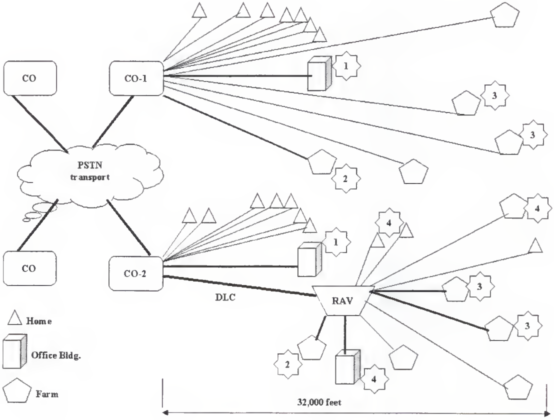

Figure 4-25: RAVs reduce subscriber to fiber distances.

CO-2 has an RAV (and DLC) able to serve more distant areas with more than basic telephone service. With the RAV, farm (2) is able to increase the speed of high-speed service since it is now closer to the fiber to CO connection. Furthermore, farms (3) are now able to access high-speed service. Indeed, as the area grows, new business parks, farms, and homes can be served by high-speed technologies. This is only true if RAV-DLC equipment is compatible with high-speed services. Over half of RAV-DLC equipment deployed by BellSouth in Florida cannot support such services as DSL.

Table 4-9 shows some of the technologies that use the telephone plant to deliver hypercommunication services in Florida. These technologies are described in context in the enhanced telecommunications, private data networking, and Internet sections (4.7-4.9).

Table 4-9: Copper access technologies that use the telephone plant.

Name	Meaning	Text	Bandwidth (data rate)	Distance (feet)	Services Supported
V.22, V.32, V.34	Voice modem protocols	4.2.2, 4.9.1	300 Hz-3500 Hz (2400 bps-28,800 bps)	32,000	Internet access, limited data communications.
V.90	"56k " modem protocol	4.2.2, 4.9.1	300 Hz-3500 Hz (33.5 kbps, upstream; 56 kbps, downstream)	<30,000	Internet access, data.
ISDN	Integrated Services Digital Network	4.7.4	BRI: 80 kHz-120 kHz (BRI 128 kbps; PRI, 1.472 Mbps)	12-18,000, repeaters extend range to 36,000, reduce bps.	Circuit-switched digital: Internet, data, PSTN (2-23 lines).
x-DSL	Digital Subscriber Line	4.7.3	0-4 kHz, 26 kHz-1.1 MHz (160 kbps-9 Mbps, symmetry varies)	<18,000-36,000, data rate falls as distance rises.	Dedicated circuit: Internet, PSTN (1+ lines), data.
DS0 frac. T	Digital	4.7.3	Around 8kHz (56-64 kbps)	12-18,000, repeaters extend to 24-36,000.	Dedicated circuit: PSTN (1 line), data, Internet.
DS1 (T-1)	Digital	4.7.3	400 kHz-1.5 MHz (1.536 Mbps)	12-18,000, repeaters (doublers) extend to 24,000 & up.	Dedicated circuit: Internet access, PSTN (up to 24 lines), frame relay, other data.
DS3 (T-3)	Digital	4.7.3	Up to 67.145 MHz (45 Mbps)	Limited copper, usually coax or fiber. Fiber range unlimited.	Dedicated circuit, Internet, PSTN (up to 672 lines), ATM, other data.

Sources: George (1998), Schlegel (1999), Paradyne (1999), FitzGerald and Dennis (1999), REA "Digital Transmission Fundamentals", BellSouth (2000).

The first two rows describe modem technologies, mostly used to allow analog copper lines to transmit Internet and data. It is also possible to use "channel bonding" to combine modems on separate telephone lines (at both ends of a connection) into a single channel to obtain higher data rates. However, analog telephone lines were designed only to accommodate voice conversations over bandwidths that rarely exceed 3.1 kHz.

If bandpass filters and other intermediate equipment (bridged taps, amplifiers, and loading coils) are removed from the lines (a process known as line conditioning), copper is capable of carrying data rates far in excess of 56 kbps modems. The usable bandwidth can rise above 1 MHz, even at distances of two to four miles. However, the availability of this greater bandwidth depends on how close subscribers are to the CO (or suitable RAV) because attenuation and noise increase with distance. Additionally, higher frequencies are inherently more sensitive to noise and interference.

Some of the access technologies shown require individual line conditioning so that only a subset of subscribers along a certain path to the CO will ever be able to obtain high-speed connections. Other copper access technologies require that every line along the entire path to the CO be conditioned so that high-speed services are available to most of the subscribers.

The first digital technology in Table 4-9, ISDN (Integrated Services Digital Network), is both a service and a technology. ISDN was meant as a circuit-switched standard that would overcome problems in the PSTN by creating a way to handle voice, data, and video traffic. There are two kinds of ISDN, ISDN-BRI (Basic Rate Interface) and ISDN-PRI (Primary Rate Interface). ISDN-BRI uses two copper wires and two 64 kbps B channels (that carry communication) and one 16 kbps D-channel (used for signaling or overhead). Both kinds of ISDN operate over the PSTN so both data and voice traffic may pass through the telephone CO, switches, and transport network.

In the late 1980's, ISDN-BRI was expected to replace modems as the copper access technology of choice. This has not ended up coming true, possibly because ISDN connection pricing was metered (per minute). Since then, while ISDN-BRI rates have fallen in many markets, superior copper loop technologies (such as DSL) have become available. ISDN changes asynchronous computer communication into synchronous data streams so computers can use standard COM ports along with a V.120 terminal adapter to communicate. Terminal adapters can tell the difference between data traffic and telephone calls so one channel of the BRI connection can be used for data or Internet while the other B channel is used for telephone calls. ISDN-PRI offers 23 64 kbps B channels and one 64 kbps D channel. Like ISDN-BRI, ISDN-PRI uses telephone switches. Both kinds of ISDN require call set-up and dial access time. Both types of ISDN are given further coverage in 4.7.4.

Another kind of technology that is sometimes called ISDN is B-ISDN (Broadband ISDN). However, B-ISDN is not a circuit-switched ISDN technology but is a protocol for cell-switched ATM (Asynchronous Transfer Mode) technology that operates at speeds of 45 Mbps to 600 Mbps. A close relative of ATM, frame relay, is a frame-switched technology that operates at speeds of 64 kbps to 1.544 Mbps and above. Neither frame relay nor ATM is switched through the PSTN, though they may use copper or fiber from a telephone company (ALEC or ILEC) in the access level. Typically, however, if ATM is the transmission technology, copper can only be used for 300 yards or so on the CPE side. In such a case, access must be by fiber because even CAT 5 UTP cannot handle 155 Mbps longer than that distance [Thorne, 1997]. These technologies (associated with private data networking, but able to support voice) are covered in more detail in 4.8.

The next access technology in Table 4-9 is X-DSL, the first of several dedicated circuit technologies. DSL stands for digital subscriber line and X stands for the over ten different varieties of DSL such as (ADSL, DSL-G-Lite, RADSL). These specific forms of DSL will be discussed in section 4.7.3 with other dedicated circuits. Provision of DSL over the telephone plant requires the absence of bridged taps and loading coils [Paradyne, 1999]. Bridged taps (open ends) are used in many areas so that future telephone subscribers will have lines ready to tap into when new homes or businesses are built in areas where future growth is expected. Loading coils extend the reach of copper in sparsely populated areas on loops over 18,000 feet that do not have RAVs.

More than twenty percent of all local loops have loading coils [George, 1998]. Additionally, many DSL varieties cannot be provided over DLCs and RAV equipment.

Also explored in 4.7.3 is DS-0, fractional T, T-1, and T-3 technologies. These are the most common leased or dedicated digital circuit technology in the United States [Tower, 1999]. One use of Ts is to carry multiple voice channels over a single twisted pair or a quad connection. Multiplexing techniques allow T-1s to carry 24 voice channels (each a 64 kbps TDM channel), while T-3s carry 672 voice channels.

Ts may be leased from ILECs or ALECs to access the PSTN for local telephone service (local T). Ts also are leased from an IXC for long-distance service or are leased from an ILEC, ALEC, IXC, or ISP to link corporate data networks nearby or overseas. Ts are also leased from the ILEC or an ALEC and terminated at an ISP for Internet access. T-1s require conditioned lines so that when used with certain signal technologies, repeaters are necessary to regenerate signals every 3,000 to 6,000 feet, with a distance of less than 3,000 feet needed from the demarcation mark and the first repeater [Paradyne, 1999, p. 6]. Newer Ts use a HDSL signaling scheme using quad copper for the full 1.544 Mbps [Sheldon, 1999, p. 942]. HDSL allows two to four times the distance of an conditioned T-1 (AMI) circuit.

T-3s carry DS-3 signals over copper or copper-coax as well, though they are now more likely to be carried by fiber optic cable. A T-3 is the equivalent of 28 T-1s with a total of 672 voice channels and a data rate of 44.736 Mbps. T-3s serve similar purposes as T-1s including voice, data, and Internet access. T-3s are typically leased from ILECs and ALECs, but when Internet is involved, ISPs are also involved as discussed in 4.9.1. Presently, T-3s are not often used as access technologies but are usually used as transport or backbone circuits (mentioned in 4.9.4). However, as agribusinesses require increasingly greater network capacity (especially as Internet, data networking, and Internet access use a single, converged hypercommunications pipeline), T-3s will become more common as access technologies.

4.3.3 Cable TV Infrastructure and Dark Fiber Networks

The telephone infrastructure is not the only way for agribusinesses to access hypercommunication networks. The cable TV plant and dark fiber networks of other potential hypercommunication carriers are additional ways. Cablecos now are focusing on introducing a variety of hypercommunications services primarily for residential suburban Florida. The list of cable services has grown from basic and extended choice television into pay television, audio programming, local telephone service, and high-speed cable modem Internet access.

Electric utilities also have rights-of-way and fiber capabilities over which hypercommunication services are offered. Electric utility fiber is often called "dark fiber" because of the enormous unused capacity in electric company fiber optic networks. There are estimates that as much as 50% of all fiber networks are overbuilt and, hence, dark [Gong and Srinagesh, 1997]. Often, this capacity is sold wholesale to telecommunications carriers. In some cases, such as GRU (Gainesville Regional Utilities) and TECO (Tampa Electric) for instance, electric companies offer data and other hypercommunication services directly to Florida businesses. In some areas, railroads and other firms also have dark fiber capacity.

This section reviews the ability of the cable TV infrastructure to provide hypercommunications access to agribusinesses in Florida. However, generalizations are difficult because of considerable technological variation offered by cablecos in various parts of Florida. In part, the variations in infrastructure are due to the size of cablecos. Cable systems range from with millions of subscribers (such as MediaOne and TCI, both owned by AT&T, and @Home, owned by Time-Warner-AOL) to franchises owned by a single person that serve a few hundred households.

Several observations are in order first. First, cablecos have traditionally focused on serving the residential market, though this is somewhat less important to agribusinesses since many are residences (farms), or are operated in or near residential areas. Second, not all cable systems have upgraded their equipment to provide data and voice services. Third, many rural areas are not served at all by cable television and may never be. Small town cable service is usually available, but conditions vary as to how far out of town the cable travels if at all. Cable TV is a monopoly franchised by cities, counties, and other geographic areas such as subdivisions, with specific service boundaries. Traditionally, state and federal regulations have not equated cable service with telephone service in terms of being a social necessity. Thus, only in localized franchise areas has an attempt been made to provide universal service to all locations.

The main reason cableco networks have become competitive with telco networks is that cablecos have lower costs of upgrading their infrastructure from coax to fiber than telcos do upgrading from copper to fiber. Furthermore, cablecos serve local franchises while ILECs are required to serve all reasonable locations in their larger coverage areas. Estimates differ dramatically on the cost per mile of replacing the local copper telephone loop with fiber.

Upgrading analog copper to FTTH (Fiber to the Home) systems capable of supporting two-way broadband services costs an average of $1,500 to $2,000 per urban ILEC subscriber [Egan, 1996, p. 152]. However, since BellSouth has a $10.4 billion wireline network infrastructure investment now in Florida and an $800 million annual construction budget in the state already, it cannot afford to completely replace access copper with fiber [Ackerman, 2000]. Cable TV providers often have significant cost advantages over ILECs when it comes to upgrading local loops with hybrid copper fiber installations known variously as FTTH, FTTC (Fiber to the Curb), and FTTN (Fiber to the Neighborhood). While expensive, cablecos can upgrade their local loops to fiber at one-fifth the cost telcos can. It will take Cox Cable five years and $400 million to rebuild the 60,000 miles of Phoenix, Arizona's cable system (which passes 1.12 million homes), at $357 per subscriber[25] [Woodrow, 1999].

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[25] Meanwhile, by Cox's own admission, Florida communities served by Cox (such as Gainesville and Sarasota) must wait until after Phoenix' fiber is laid before they receive upgrades in their infrastructure. [Woodrow, 1999]

Figure 4-26 shows the set up for four typical cableco infrastructures. Note on the left the head end. This is similar to the telephone company CO in that it is a physical office where cable company equipment is located and where the cable runs for an area converge. However, the head end is linked to two transport networks (the PSTN and the Internet) and is connected to satellite equipment so TV signals may be downloaded. In digital cable systems, the head end also is equipped for digital cable TV signaling.

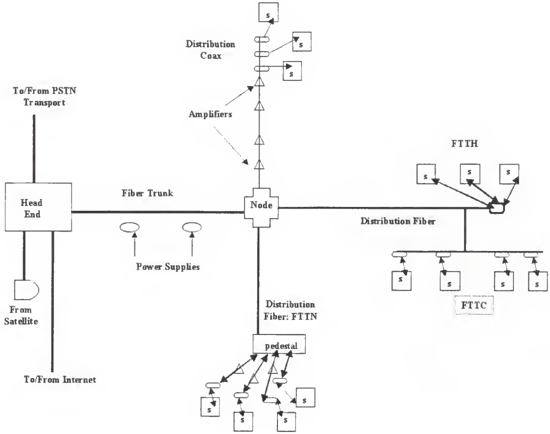

Figure 4-26: Cable TV plant showing one-way, FTTN, FTTC, and FTTH distribution.

Regardless of which distribution scheme is used, the head end must be equipped to support Internet and PSTN as depicted. From the head end, a fiber trunk (with power sources required) leads to a node that serves from 500 to 5000 locations. From the node, there are four distribution schemes shown.

The first distribution scheme serves subscribers (s) through distribution coax (top), with amplifiers required to boost the signal enough that it reaches the tap point, from which lower capacity coax is dropped to each home or business. The first distribution scheme may be over 350 MHz coax so that a maximum of 58 TV channels may be received along with download only Internet access. Upload Internet access is via modem over standard analog telephone lines, with downloads accomplished with a one way internal cable modem such as a Surf Board.

The second distribution scheme (bottom, Figure 4-26) is FTTN (Fiber to the Neighborhood). Two-way broadband services could be provided to these subscribers, with fiber optic cable running to a neighborhood pedestal where coax cables distribute amplified signals to homes. A lower capacity (un-amplified) coax leads from the tap point to the service connector(s) within each subscriber's location. FTTN supports two-way services including Internet, enhanced telephony, and digital cable. Over 100 TV channels may be received via FTTN as well.

The third and fourth distribution schemes, FTTC (Fiber to the Curb or Fiber to the Cabinet for small businesses) and FTTH (Fiber to the Home) are shown on the right of Figure 4-26. FTTC (on the bottom right) uses fiber optic cable to reach curbside tap points and then uses un-amplified drop coax from there to the service point inside each location. Under FTTH (top right), low capacity fiber is run from a neighborhood pedestal to each home. Both FTTH and FTTC can support two-way broadband services including digital cable TV, VOD (Video on Demand), data networking, Internet, and enhanced telephony. Over 120 TV channels may be received using FTTC, with a specialized set top box capable of preprogramming and downloading pay-per-view VOD and pay channels as well as displaying specialized system information.

In FTTN and FTTC, data connections are supported with ordinary 10BaseT-Ethernet cards and connections similar to an RJ45 lead from CPE DTE to on-premise coax and then to tap points. A two-way cable modem (such as the LAN City LANtastic or Toshiba PCX1100) is used with FTTN and FTTC systems. Current FTTH connections use coax inside the home, but fiber to desktop CPE are being introduced. Eventually, FTTH will support bit rates many times that of VDSL (up to 200 Mbps) [Schlegel, 1999].

The capacity of many older analog coax cable systems is 350 MHz and below. However, the latest HFC (Hybrid Fiber Coaxial) voice, data, and TV systems run at 750 MHz and more. A 6 MHz downstream channel capable of 27-36 Mbps is shared among an average of 500 to 2,000 users per node [George, 1998, Table 2-1]. The upstream link of 2-5 Mbps is also shared with other users on the node. However, it would take a critical mass of over 200 simultaneous users per mode for a significant degradation of up or downstream data rates to be experienced with the broadband shared access approach [Reed, 1997].

Because of the shared access broadband signaling inherent in cableco access, it is often not considered a business-class service. Connections can support only up to five computers per location, and there are certain security concerns that require defensive cableco installation. Only a few telephone lines per customer can be supported because of the upstream limitations. However, FTTH applications are being developed that are expected to improve upstream capacity and make cable more attractive as a communications choice for business.

The availability of agribusiness cable access depends on several factors. First, in many areas, the infrastructure does not support even one-way cable modems. Service depends on the infrastructure level the cableco has implemented. Second, the more fiber is used, the more expensive intermediate DCE is required to support the network. FTTH requires that subscribers buy an expensive fiber optic transceiver known as an ONU (Optical Network Unit). With FTTC and FTTN, fiber optic equipment costs are spread among groups of subscribers. Third, telephony implementations are still in introductory stages so that service interruptions and other problems may be common in some areas. Finally, the ability to support the cost of the infrastructure depends vitally on per subscriber revenues. In low-density areas, costs per-subscriber may be too high to extend service and the cableco is rarely required to do so. However, cablecos tend to have better overall infrastructures than telcos for offering cheap, high-speed service in densely populated areas. Telcos have begun to offer cable TV and high-speed hybrid fiber coax services on a limited basis to compete with cablecos. Eventually, cablecos will support multi-telephone lines for small businesses.

Dark fiber networks provided by other carriers such as electric utilities and railroads have the same access and distribution problems that cablecos do. However, the electricity companies have an additional problem caused by the interference of electricity itself. Nortel and other companies have been experimenting with powerline networks where data can be carried within an office through electrical outlets at speeds of up to 1 Mbps, but a variety of technical problems remain. Currently, electric and other dark fiber carriers, tend to wholesale their fiber capacities to transport level carriers and customers, rather than attempt to establish access networks to smaller, local customers. Capacities can range from 45 Mbps to over 100 Mbps, though such speeds are available on a limited basis.

Before moving to transport wireline technologies, it is important to characterize the symmetry and data rates of the wireline access technologies covered thus far in 4.3. When the data rate differs between upload and download (as it does for DSL and V.90 modems), the technology is said to be asymmetric. Indeed, this can be true in some cases due to asymmetric bandwidth, when the upload capacity (in kHz, MHz, etc.) is smaller than the download capacity. The asymmetry is also linked to the use of line codes that take advantage of the fact that for applications such as the Internet, more bits are downloaded than uploaded.

Figure 4-27 compares the data rate symmetries for a voice line with V.90 modem, ISDN-BRI, xDSL, ADSL, T-1, and cable modems. The first column in Figure 4-27, an analog voice line, is asymmetric in that for the 56 kbps modem, download can occur at a rate up towards 56 kbps, while upload can only approach 33.6 kbps. Similarly, the two forms of DSL shown are asymmetric. However, ISDN-BRI, T-1, and ISDN-PRI (not shown, but same data rates as T-1) are symmetric. Cable refers to the data rate of cable modems (covered in 4.3.3).

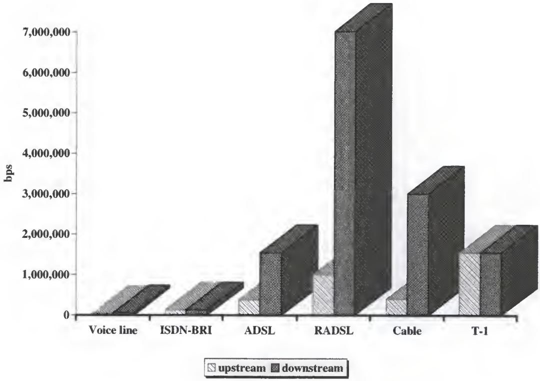

Figure 4-27: Data rate symmetry among wireline transmission technologies.

4.3.4 Data and Voice Transport, Fiber Optic Backbones

Larger agribusinesses with advantageous locations may be able to gain direct access to the transport network without having to use the access level at all. While this solution is currently an expensive one, it provides the greatest bandwidth possible. Fiber optic connections may be available from ILECs, ALECs, IXCs, cablecos, ISPs, and electric companies. As fiber miles increase and as DWDM increases the capacity of existing fiber optic connections, prices are expected to fall while supply shifts right. However, the results are uncertain.

SONET (Synchronous Optical Network) is an ECSA (Exchange Carriers Standards Association) ANSI standard for fiber optic networks. SONET defines optical carrier (OC) transport standards and STS (Synchronous Transport Signaling) for a hierarchy of fiber optic networks, primarily above the physical layer [Nortel, 1996]. While SONET is covered in more detail in 4.7.3 (as a dedicated circuit technology) and in 4.8.4 (as a private data networking technology), two important features need discussion here.

First, SONET is an "on net" wireline technology that requires direct connection to a backbone network to support a full-range of hypercommunication services. Second, SONET is fast, specifying data rates of from 51.84 Mbps (STS-1, OC-1) to 9.953 Gbps (STS-192, OC-192). Clearly, with these kinds of speeds, present agribusinesses who require SONET "on net" fiber optic connections would be large indeed.

The smallest fiber optic backbone connection is a T-3, the equivalent of 28 T-1s with a total of 672 voice channels and a data rate of 44.736 Mbps. By comparison, an OC-192 has over two hundred times the capacity of a T-3, with a minimum number of voice channels near 150,000. Specialized ONUs, smart building wiring, and other equipment are also needed to support fiber optic access/transport.

4.4 Wireless Transmission Technologies

Wireless transmission technologies are particularly important for Florida agribusinesses for three chief reasons. First, over 48 million Americans have jobs that require that they be mobile much of the time [Zaatari, 1999, p. 135]. It is likely that this is especially true for the agribusiness sector because of the land-based and international aspects of agriculture. A second reason for the importance of wireless technologies is that wireless can offer cheaper and faster rural access to hypercommunications in unserved areas than wireline. While many promising wireless technologies are being introduced in urban Florida, the advantages of using wireless over wireline technologies have been strongly supported by studies concerning rural access to advanced hypercommunication networks [NTIA, ***Survey of Rural Information Infrastructure Technologies***, 1995, p. 5-8, p. ix].

An understanding of wireless is important to agribusiness for a third reason: wireless technologies are the fastest-growing segment of telecommunications today. According to Core

Exchange, Inc., almost eighty percent of U.S. business Internet users will use wireless devices to access data in 2001, up from three percent in the year 2000 [*AIM Research Update*, 3(8), 2000]. The popularity of wireless may be related to several factors including falling prices, rising QOS, and an array of new services and devices. For example, from December 1997 to January 1999, cellular prices fell at an annualized rate of 8.4 percent while local (wireline) services increased by 2.2 percent. The overall CPI increased by 1.9 percent in the same period [FCC, June 24, 1999, FCC 99-136, p. 22-23].

Wireless technologies are easily confused with the services they deliver. Generally, most of the specific service sub-markets described in 4.6 through 4.9 are available through either guided media (wireline) or unguided media (wireless). Wireless technologies specifically designed to provide a particular service (for example cellular telephone) are given more coverage in the section concerning that service's sub-market. For example, specific wireless technologies used to deliver Internet access (4.9) or enhanced telecommunications services (4.7) are discussed in the sections concerning those sub-markets, along with their wireline counterparts.

This section focuses on wireless transmission technologies in general, especially on the access level. The introduction to electromagnetic spectra in 4.4.1 provides a foundation to understanding wireless technologies. Some examples of wireless spectra (transmission media) include: infrared, laser, microwave, and radio. Each medium (along with variations within that medium) uses a different spectral range constrained by a set of properties that depend on the physics of the electromagnetic waves in that range. Terrestrial wireless technologies (4.4.2) use earth-based wireless equipment to beam communication signals to fixed, nomadic, or mobile users. Satellite wireless technologies (4.4.3) use space-based equipment to beam communication signals to fixed, nomadic, or mobile ground-based receivers. Finally, wireless QOS is addressed in 4.4.4.

The hurried reader may be able to understand the main wireless technologies by consulting Table 4-10 (terrestrial mobile technologies), Table 4-11 (terrestrial fixed technologies), and Table 4-12 (satellite fixed and mobile technologies). Table 4-14 summarizes the QOS concerns related to wireless technologies.

The ability of wireless technologies to provide access to services that previously could only be accessed via wireline technologies led Stone to conclude, " . . . the once sharp division between wire and wireless has now closed. The markets have converged." [Stone, 1997, p. 155] Nonetheless, there are two important divisions in wireless technologies. The first division depends on the type of transmitter (terrestrial or satellite). However, wireless technologies and services have a second division based on how much the user's location varies. Wireless users may be mobile, nomadic, or fixed. A mobile user is one who travels (often by car) from one point to another within a local coverage area or roams across the state, nation, or world. Nomadic users stay in one localized area of up to a few miles, but require the ability to roam (usually by foot) within that area. A fixed user uses wireless service at one permanent location so that receiving points are stationary, similar to wireline users [Weinhaus, Lagerwerff, Brown, *et al.*, 1999].

Importantly, wireless transmission over the last mile may connect to wireless or wireline CPE at the agribusiness. Similarly, wireline equipment over the last mile may connect to wireless or wireline equipment. Specifically, Figure 4-28 shows a wireless QOS reference model.

Figure 4-28 demonstrates that, like wireline, wireless transmission has three levels: local CPE, access level, and transport level. When the local level is wireless, a wireless LAN or a local nomadic technology (such as a cordless telephone) is being used. For example, LAN wiring may be replaced with infrared signals that create a wireless path from end server (stationary LAN) to nomadic or fixed client devices. When the access level is wireless, a wireless path from customer antenna to wireless POP (base station) is required. For example, the cellular telephone creates a wireless path from a mobile phone to a base station to replace the wireline local loop from subscriber to CO. Finally, if the carrier network is wireless, a wireless transport technology is used. Bulk transmissions of telephone calls commonly use microwave or satellite paths to replace fiber optic cables. As in the case of wireline transmission, wireless transmission technologies may be point-to-point or multipoint. Most applications of wireless technologies involve hybrid wireline-wireless networks because some levels use wireless technologies to establish wireless communication paths, while others rely on wireline technologies to create wireline communication links.

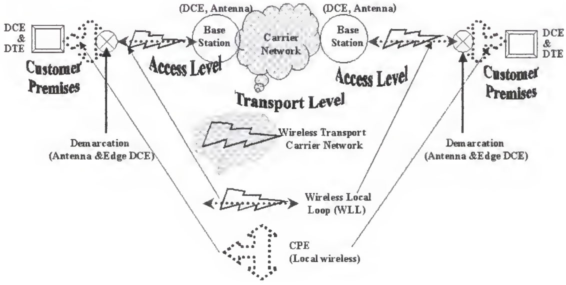

Figure 4-28: Wireless reference model shows local, access, and transport wireless.

The role of DCE and DTE differs from the wireline case. Many wireless devices are both DTE and DCE, with DAC and ADC accomplished through circuitry in the transceiver. A receiver and a transmitter (transceiver) are needed when air is used instead of wire for two-way communications. To transmit successfully, a threshold signal power is needed, while to receive, some form of antenna is required. Wireless communications has two "power challenges". First, path loss occurs when an antenna transmits a signal over air. Unlike guided media, where the entire signal (less attenuation) is received on the other end, the electromagnetic waves of unguided media are scattered through the air on their trip to and from the receiver. Second, power constraints (such as battery life or interference limitations on signal wattage) may prevent devices from transmitting a strong signal [Committee on Evolution of Untethered Communications, NRC, 1997].

Before proceeding to the electromagnetic spectrum discussion in 4.4.1, a short explanation of the generations of wireless technologies puts path loss and power constraints in the appropriate technological context. Most sources argue that there are three generations of wireless technologies, with a fourth yet to be created [NSF, 1998; Zaatari, 1999]. According to Zaatari (1999), in the first generation, analog transmission predominated. AMPS (Advanced Mobile Phone Service) and early CDMA (Code-Division Multiple Access) are two mobile wireless technologies from this era. The CDPD (Cellular Digital Packet Data) standard was established to allow an operational bit rate of 19.2 kbps over the analog AMPS systems, though actual data rates are closer to 5-10 kbps [Telecommunications Engineering Centre, 2000]. Most fixed services (such as microwave relay or fixed satellite) were used only by telephone carriers or TV stations since the technology that supported them was expensive and few other uses existed for high-bandwidth links.

In the second generation, FDMA (Frequency-Division Multiple Access) was originated when digital cellular became a more common wireless service. It was the first of many wireless technologies that allowed multiple mobile users to share the same spectrum. The 200 kHz GSM (Groupe Speciale Mobile) radio band was opened (using a European technology), digital-only service was introduced in the 1900 GHz PCS band, and dual-mode analog cellular technologies began to operate near 800 MHz. Data rates rose to 9.6 kbps and 14.4 kbps.

A scarcity of spectrum limited the extent of the market, so most second generation wireless technologies concentrated on the efficient use of already assigned spectra by increasing capacities of existing (first generation) DCE. In the US, TDMA (Time-Division Multiple Access, IS-4 & IS-136) was developed allowing three times the traffic of its first generation predecessor, AMPS. The European TDMA standard and new iterations of GSM increased existing AMPS capacity by a factor of eight. Another US standard, CDMA (IS-95) allows up to ten times the

AMPS capacities using existing spectra. Now, competing carriers use all three in the United States. Fixed and nomadic wireless technologies supported either limited common carrier offerings or private, high-speed digital TV and telephone carrier transport.

In the third generation, three competing standards (backward compatible with existing networks) increase mobile and nomadic data rates even further and allowed deployment of new services. These three are W-CDMA (Wideband CDMA), CDMA-2000, and UWC-136 (Universal Wireless Communications). Third generation wireless technologies will (or are already able to) support Internet access, worldwide roaming, and video conferencing in addition to enhanced wireless voice for mobile users [Zaatari, 1999, p. 133]. All three support mobile data rates of 384 kbps (extended range) and 2 Mbps (mobile, nomadic or fixed, local range). The three competing standards are assigned frequencies in the Broadband PCS and 2 GHz bands.

Another group of technologies of the third generation serve fixed wireless users, offering greater data rates. A promising source of wireless hypercommunication technologies came in the area of wireless "cable" and fixed broadband wireless access. Wireless cable is primarily comprised of MDSs (Microwave Distribution Systems) such as MMDS (Microwave Multipoint Distribution System) and LMDS (Local Multipoint Distribution System). Wireless cable was developed initially to supply cable TV programming to rural locations, thus allowing competition with wireline cablecos. MMDS is the wireless equivalent of broadband communications offering cable TV, Internet, basic telephony, and enhanced telecommunications services.

New technologies and devices have been developed recently to allow LMDS and MMDS to carry two-way data and multiple voice lines. Satellite DBS (Direct Broadcast Systems) offer high-speed Internet access. Wireless LAN technologies allow local CPE networks to function without wires so network users can move about a business' location with portable computers, telephones, and other devices.

In Figure 4-29 [Adapted from NSF, 1998], the four generations are depicted graphically, summarizing where current wireless transmission technologies fit compared to wireline and future wireless generations. The bottom x-axis depicts the transmission rate (operational bit rate), while the y-axis depicts the degree of mobility. To make comparison easier, at the very bottom (spanning all transmission rates), are boxes containing wireline conduit types.

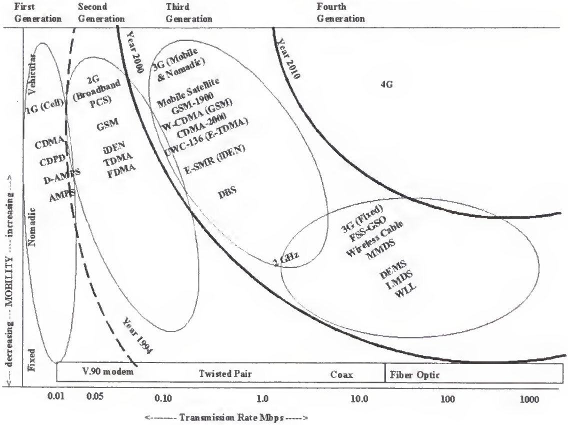

Figure 4-29: Second, third, and fourth generation wireless services.

The capstone of the third generation will almost certainly be high frequency, fixed wireless technologies that allow two-way access to a full range of hypercommunication services. Concentrated in the SHF (Super-High Frequency) and EHF (Extremely-High Frequency) bands from 3 GHz to 39 GHz third generation services include DEMS (Digital Electronic Message Service), Ka-band FSS-GSO satellite, Big LEO satellite, LMDS, and Winstar's 39 GHz WLL. Third generation fixed wireless technologies are beginning to provide high-speed services rivaling fiber optic data rates. Power, antenna, and tower relay technologies for some of these services are still under development.

However, the NSF Tetherless T-3 Workshop Report found that the third generation "vision of providing any service to any user at any time anywhere on earth will be only partially achieved by the current technology." [NSF, 1999, p. 2-13] Hence, the development of a fourth generation of wireless technologies is envisioned as necessary for wireless to become a truly mobile, high-speed worldwide method of hypercommunications. Bold isoquant-like curves separate generations in Figure 4-29, with third generation technologies expected to evolve from their introductions in 2000 until the fourth generation begins, sometime near 2010.

4.4.1 Technical overview of electromagnetic spectra

Further clarification of the electromagnetic spectrum will help make the brief, technical introductions to terrestrial (4.4.2) and satellite (4.4.3) technologies more understandable. It is important to note that 4.4.2 and 4.4.3 build on the material presented here in 4.4.1. In this sub-section, the purpose is merely to outline the spectral properties of frequencies associated with wireless technologies. More details about each technology and the services it supports will be found in the sub-sections following.

Physicist James Clerk Maxwell addressed the Royal Society in 1876 with a revolutionary paper showing the existence of the electromagnetic spectrum. Maxwell found that "Electromagnetic fields could be propagated through space as well as conductors" and "light itself was electromagnetic radiation within a certain wavelength" [Stone, 1997, p. 131]. By 1894, English physicist Oliver Lodge came up with systems by which wireless signals were sent and received. However, he could not see any commercial applications. Guglielmo Marconi obtained the first radio patent in 1896 and demonstrated radio's applicability to navigation. Then in 1901, Marconi transmitted an "s" in Morse code from Cornwall, UK to Newfoundland. Marconi's success led to a scientific race to explain the results, ending in the postulation that layers of the ionosphere refracted short, medium, and long waves to earth [Stone, 1997]. Since that time, as scientists have created new wireless technologies, commercial application has waited for FCC assignment of frequencies and bandwidths for new services, for the perfection of DCE and DTE, and for the launch of new services.

Now, the electromagnetic spectrum consists of:

> The range of frequencies of electromagnetic radiation from zero to infinity. . . . formerly divided into 26 alphabetically designated bands. ...The ITU formally recognizes 12 bands from 30 Hz to 3000 GHz. New bands, from 3 THz to 3000 THz, are under active consideration for recognition. [FCC, 1996, p. E-10]

Wavelengths of electromagnetic spectra are measured in meters, while frequencies are counted in Hertz. Based on both measures, groups of frequencies are categorized into bands. The frequency of a signal is a function of the wavelength of the carrier. If f is frequency in MHz and w is wavelength in meters, then w=300/f and f = 300/w. The wavelength is important in determining the size of the antenna.

In wireless transmission, bandwidth has a broadcasting orientation similar to how radio and television channels are defined. Barden defines the bandwidth of a broadcast signal as: "Total width of a radio signal, varying from a few hundred Hz for CW to five or six MHz for TV." [Barden, 1987, p. 109] In general, the wider the bandwidth, the greater the interference. The potential of wireless is especially apparent when the bandwidth of an analog telephone line (3.1 kHz) is compared to WLL upper-band services that reside at 39 GHz, over twelve thousand times larger.

However, the requirements for receiving and sending high-speed wireless hypercommunications traffic vary according to the frequency band, bandwidth, availability of inexpensive equipment, equipment power, antenna type, terrain, and other factors specific to the spectrum used by a particular device. Interference or noise may result from rain, lightning, wind, outer atmosphere conditions, sunspot activity, solar flares, mountains, ground clutter, soil conductivity, interference from other devices, and due to the quality of filtering mechanisms in receiving appliances.

In the US, the FCC allocates spectrum among several groups: scientific interests, governmental and military users, broadcasters, amateur and private operators, and common carriers. Figures 4-30 and 4-32 through 4-33 show some of the more important spectrum assignments resulting from recent FCC licensing, auctions, and legislation. Assignments are far more detailed than those shown [NTIA, 1997; FCC, 1996; Weinhaus, Lagerwerff, and Brown, 1999]. Some wireless services require the action of local governments as well to cross public and private rights-of-way or to compete with wireline cableco franchises [Matheson, 2000].

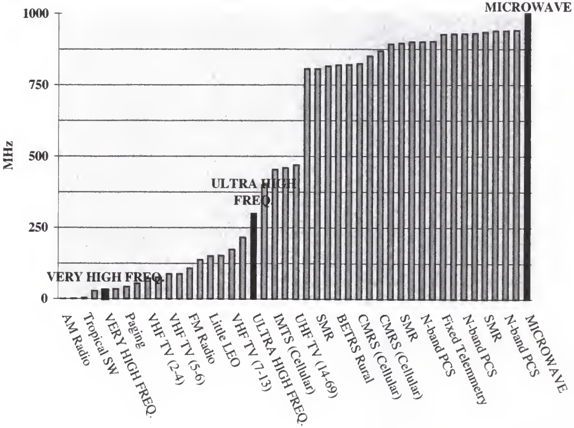

Figure 4-30: Electromagnetic spectrum (one of three) from AM radio to microwave.

The lower frequencies are familiar since they contain AM radio, FM radio, and VHF and UHF TV bands. Indeed, most first generation and a good part of second generation wireless traffic is carried in the VHF (Very High Frequency) band and sub-microwave part of the UHF

(Ultra High Frequency) band, the range shown in Figure 4-30. Beginning at the left, are the AM radio and tropical short-wave bands. The so-called tropical short-wave bands (below 3.950 MHz, wavelength 76 meters) are allocated to countries where interference-causing thunderstorm activity is common. These frequencies have less atmospheric noise due to lightning burst or static noise. Furthermore, since low-power transmitters can be used in those frequencies, radio signals can cover a greater area relatively inexpensively.

Moving to the right of Figure 4-30, other short-wave frequencies are found. It is possible to communicate via SSB (Single Side Band) radio in short-wave bands for thousands of miles to land or sea with specialized radio equipment. Motorola offers radios capable of sending data, voice messages, faxes, and e-mail using SSB paths. Equipment is expensive and interference can be great, so there is no guarantee traffic will get through to the destination.

The VHF band begins just above the CB (Citizen's Band) at 30 MHz (wavelength, 10 meters). Until 30 MHz, atmospheric noise is plentiful while attenuation is low, meaning short-wave radio signals can be transmitted thousands of miles. Atmospheric noise drops at 30 MHz, but from 30 to 300 MHz, cosmic noise occurs and terrestrial signals cannot be transmitted beyond 50 to 120 miles, depending on terrain. VHF-TV, FM radio, and Little LEO technologies are used to communicate over frequencies in this spectrum. Little LEO systems are used for paging and low-speed data transmissions such as for POS (Point-of-Sale) devices.

From 300 MHz and up, line-of-sight wave propagation occurs [Committee on Evolution of Untethered Communications, NRC, 1997]. While short-waves[26] bounce off levels of the ionosphere to travel hundreds of miles, meter-long (UHF) waves and 0.3 meter microwaves normally do not go beyond the 60 km (37 miles), the line-of-sight from transmitter to receiver

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[26] Contrary to their name, short-waves are longer than waves at higher frequencies. The term short is a relative one, meant to compare short-waves with low-frequency long-waves that are below the AM band.

[NTIA, 1995]. As frequency rises, coverage distances shrink, though this phenomenon is more pronounced in mobile communications.

Figure 4-31 shows an example of the relationship between the coverage zone of a single transmission tower to an increase in frequency using a mobile radio simulation done by NTIA's engineering arm, ITS (Institute for Telecommunications Sciences) [NTIA, 98-349, 1998].

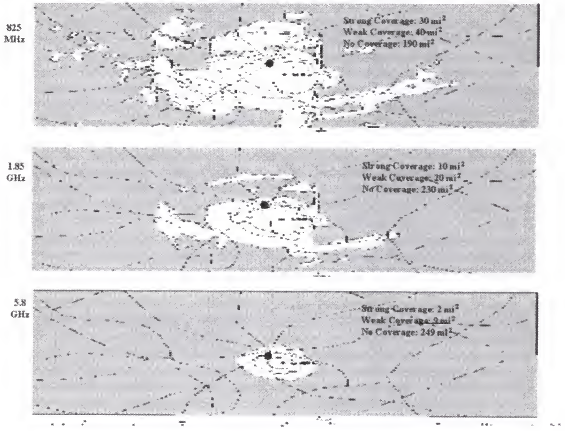

Figure 4-31: As frequency rises, coverage zones become smaller.

This physical relationship was behind the development of research on cellular and other mobile wireless coverage. To increase the coverage area for a given frequency, power must be boosted or antennas made taller or an interlocking network of base stations must be established (each with an overlapping coverage zones) or all three tactics taken. By using a combination of methods, the footprint of a particular wireless carrier (sum of individual coverage zones) can grow.

The FCC represents another limitation on coverage zone sizes and footprint areas because it regulates power levels and frequencies used by most wireless spectra. Specific boundaries are discussed in 6.1, but most frequency allocations are assigned on a market by market basis through open auctions or existing licensing regulations.

However, as frequency increases, signals cannot reach places they would have at lower frequencies even with the same signal power and antenna height. Hence, more towers are needed, more closely spaced together as frequencies rise. The irregular shape of the coverage zones in Figure 4-31 is due to terrain differences, water bodies, forested land, and other factors. With fixed services, special gain antennas can be aimed directly at the transmitter, resulting in larger coverage zones (at equal frequencies) than for mobile technologies.

Since satellite signals do not contend with (land-based) horizontal interference because line of sight is defined from outer space, a satellite can cover a vastly larger area than a terrestrial transmitter on the same frequency. However, satellite transmitters need more power to transmit while satellite dishes (designed as cones to increase the gain or signal power) have to be aimed at certain angles to pick up (and transmit) signals from and to outer space. In addition to frequency, antenna type, antenna direction, user mobility, and the specific terrestrial or wireless technology used affect the size of the coverage zone.

Most first generation and some early second generation wireless traffic takes place within the UHF (300 MHz) to 1 GHz (microwave) frequencies shown on the right side of Figure 4-30. Most prominent are UHF-TV, and two forms of cellular service IMTS (analog cellular) and CMRS (digital cellular). The SMR (Specialized Mobile Radio) bands use iDEN™ technology to provide a combination of radio and cellular communications to customers. Narrowband PCS telephones and pagers use this part of the spectrum as do fixed telemetry (remote sensing) devices. The BETRS (Basic Exchange Telephone Radio Service) rural radiophone service also is found here. BETRS offers small, remote communities the opportunity to use a radio transport path for telephone transport when wiring or cable is expensive compared to the subscriber base, impractical, or environmentally unsound. Around one hundred telephones on Dog Island, a small island on the Gulf coast near Carabelle, use this service to connect to the PSTN. ISDN-BRI is available through BETRS [FPSC, Docket 950814-TL, Order PSC-97-1196-FOF-TL, 1997].

Moving up, frequencies above 1 GHz have wavelengths so short they are too small to be called radio waves. Instead, these high frequencies above 1 GHz are called microwaves since they are one-millionth the wavelength of a 1 Hz wave. Figure 4-32 depicts part of the microwave spectrum, from 1 GHz microwaves (300 mm wavelength) up to 10 GHz (30 mm) in the SHF band. Later-second generation and third generation mobile and early third generation technologies that support fixed services operate in this spectral segment.

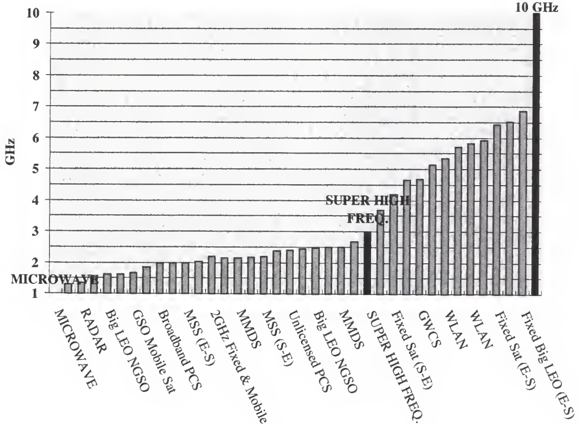

Figure 4-32: Electromagnetic spectrum (two of three) microwave to 10 GHz.

Two mobile satellite technologies, big LEO (Low Earth Orbit) and GSO (Geosynchronous Orbit), use the spectrum between 1 GHz and the 2.45 GHz frequency (used by microwave ovens), providing telephony and narrowband data communication. Also in this range are broadband PCS technologies, along with two other terrestrial technologies. First, two technologies that support newly auctioned fixed and mobile services at 2 GHz are located there, as is a third technology, MMDS (Microwave Multi-point Distribution System). These three terrestrial technologies are now (or soon will be) capable of providing data rates up to 2 Mbps in localized coverage areas and below 300-400 kbps in extended coverage areas. However, some argue that these promised speeds are higher than reality. For example, mobile users using PCS-1900 standard GPR (General Packet Radio) will have bit rates in extended areas of as low as 115 kbps because of the effect of motion on the radio path [Telecommunications Engineering Centre, 2000].

MSS (Mobile Satellite Service) technologies, fixed satellite, big LEO satellite, and additional point to multi-point terrestrial MMDS technologies have frequency allocations around 3 GHz. In the SHF band from 3 GHz to 10 GHz, several satellite technologies (GWCS or General Wireless Communications Service and other fixed satellite services) operate in frequencies near fixed WLAN (Wireless Local Area Network) technologies.

Figure 4-33 depicts the frequencies from 10 GHz to 59 GHz. From 10 GHz to 20 GHz a variety of satellite technologies share FCC-assigned commercial frequencies. These commercial frequency bands include broadband satellite Ku-band, DBS (Direct Broadcast Satellite), additional Big LEO frequencies, and several other fixed satellite assignments.

Enormous interest exists in development and introduction of services that would use fixed terrestrial technologies to provide services that would operate in the 24 GHz to 39 GHz (upperband) microwave frequencies. Broadband fixed wireless technologies in the upperband range include DEMS, LMDS, MMDS, and WLL. Because wavelengths are smaller, antennas are small enough (15 by 15 cm) that large, expensive rooftop antennas are unnecessary. The short wavelengths of the upperband range are not true line of sight systems because buildings or structures that might normally obstruct signals serve as passive or active repeaters since signals bounce off them or around them [Telecommunications Engineering Centre, 2000].

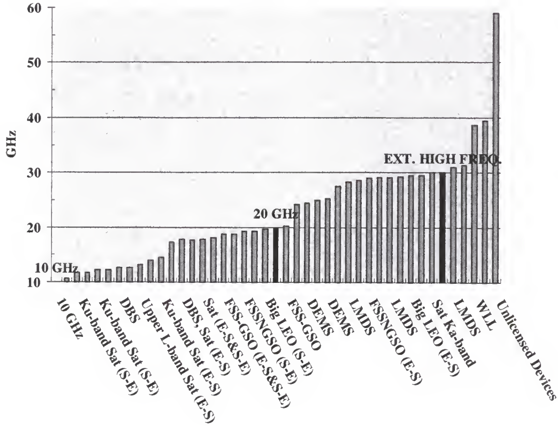

Figure 4-33: Electromagnetic spectrum (three of three) above 10 GHz.

Hence, while a form of line of sight propagation exists (with smaller coverage zones) above 30 GHz in the EHF band from transmitter to receiver, customers need not resort to large, roof-mounted antennas [Committee on Evolution of Untethered Communications, NRC, 1997]. However, there is a new set of limitations in the upperband. According to the NTIA, "beginning at about 10 GHz, absorption, scattering, and refraction by atmospheric gases and hydrometeors (the various forms of precipitated water vapor such as rain, fog, sleet and snow) become the important limiting factors for electromagnetic wave propagation" [NTIA, 1995, part 2, Ch. 8].

Other important concerns are possible affects on human health of all microwave transmissions, especially those in the upperbands.

Above the range shown in Figure 4-33, lasers and infrared light are also used, mainly for WLAN applications. During every wireless generation, there has been a frequency shortage followed by new technologies (and regulations) that allow ever-higher frequencies to be harnessed for communications. Laser and infrared technologies are currently used for short distances such as within buildings or from one building to an adjoining building for data networking. TV remote controls are examples of laser or infrared devices. Like remote controls, lasers and infrared signals require close, unobstructed ranges to operate.

Figure 4-34 shows how rain, fog, and atmospheric gases (such as water vapor) can limit signal strength (and hence the coverage zone of a single tower) as higher wireless frequencies are used [NTIA, 1995].

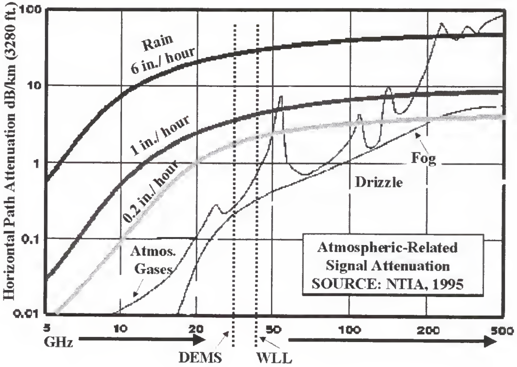

Figure 4-34: As frequency rises, rain and other atmospheric conditions lower signal strength.

On the x-axis are frequencies from 5 GHz to 500 GHz, with special attention drawn to the upperband between DEMS and WLL (from 24 GHz to 39 GHz). The y-axis depicts horizontal path attenuation (dB/km), showing how much signal strength is reduced due to various rainfall rates, fog, drizzle, and atmospheric gasses. If every 3 dB of signal loss results in the loss of 50 percent of a signal's remaining strength [Sheldon, 1998, p. 995], then the heavier the rain and the higher the frequency, the more likely the signal will suffer. The 3 dB threshold is reached just above 6 GHz for rain falling at a rate of six inches an hour and below 20 GHz for rainfall rates of one inch an hour. The threshold is reached within the upperband with rainfall rates of one -fifth an inch per hour, but not for drizzle. Atmospheric gases cut signal strengths in half only at frequencies well above the 39 GHz band where WLL technology operates.

Upperband technologies can be engineered around these problems through a site specific trial and error approach using early customers as experimental subjects. Nor is there scientific agreement about what kinds of reception problems can be expected. According to NTIA (1995) research, for every km (3280 feet) that an upperband signal travels through rain (falling at a rate of an inch or more per hour)[27] result in as much as a 75 percent signal reduction. Papazian, *et al.* (2000) found that trees in wind (located near business wireless equipment) could be worse than rain in reflecting or blocking upperband signals.

More generally, path loss, shadow fading, multipath fading, and interference are all problems that affect terrestrial wireless transmission. Path loss equals received power divided by transmitted power and is a function of distance from transmitter to receiver [NRC, 1997]. More formally, path loss, L is given by $L = \frac{Pr}{Pt} = \frac{K}{f^2 d^n}$, where Pr is received power, Pt is transmitter power, f is the center frequency of the signal, and n is the path loss exponent. K is a constant that depends on path loss at a reference distance d_0 from the transmitter, or the antenna far field (approximately 1 m indoors and 0.1-1 km outdoors) [NRC, 1997, p. 2-34]. Hence, "received signal power is proportional to the transmit power and inversely proportional to the square of the transmission frequency and the transmitter-receiver distance raised to the power of a path loss exponent." [NRC, 1997, p. 2-34]

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[27] The *rate* of rainfall is what is important, not whether it lasts an entire hour. For example, if an inch of rain was received in ten minutes, that would equate to a six inch an hour rate, as would sixteen hundredths of an inch in ten minutes equal a one inch per hour rate.

Given that the path loss exponent is 2 in free space, but ranges from 3 to 5 in typical outdoor environments, exceeding 8 with dense buildings or trees,

> . . . systems designed for typical suburban or low-density urban outdoor environments require much higher transmit power to achieve the same desired performance in a dense jungle or downtown area packet with tall buildings. [NRC, 1997, p. 2-34]

As frequency rises, path loss tends to rise, while as distance increases, path loss rises as well.

The technical details of wireless transmission are subject to Shannon's Law, the Nyquist Theorem, and other physical laws governing analog-digital conversions and signal domain as discussed in 4.2. Gilder argues that the future of wireless is "boundless bandwidth, accomplished by the Shannon strategy of wide and weak signals, moving to ever smaller cells with lower power at higher frequencies." [Gilder, 1993, p. 11]

In spite of such a bright future, there are three important differences between wireline and wireless transmission *as currently provisioned* that should be noted before specific terrestrial and satellite technologies are covered. The first difference is that many mobile wireless CPE devices contain DTE, DCE, and an antenna in one unit. For fixed wireless technologies, there is typically more separation. Figure 4-35 (based on NTIA 98-349, 1998, p.2) shows the components of a general wireless technology, operating at the local network or access level.

DTE perform DSP (Digital Signal Processing), analog-digital conversion (when needed), and interact with the user via display and controls. DCE are transceivers with power settings and electronics components for particular frequencies that send and receive RF (Radio Frequencies), microwaves, infrared, or other wireless signals. Then, for most carrier services, signals are sent over antennas, typically to a base station or tower that has intermediate DCE and antennas of its own. If the opposite end is wireless, the process is reversed. Wireless mobile and nomadic telephones (and other mobile user devices) contain all three components in a single unit.

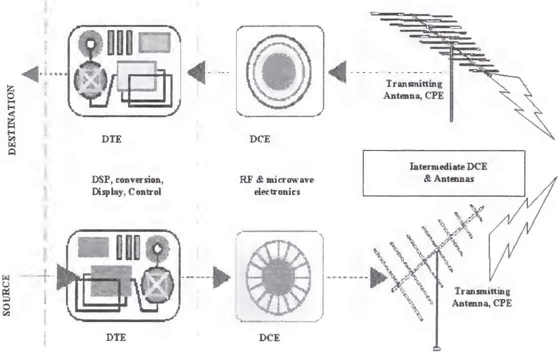
DESTINATION
Transmitting Antenna, CPE
DTE
DCE
Intermediate DCE & Antennas
DSP, conversion, Display, Control
RF & microwave electronics
SOURCE
Transmitting Antenna, CPE
DTE
DCE

Figure 4-35: Wireless technology components may be separate or together.

However, fixed wireless connections typically have the antenna separate from the DCE and DTE. When a computer is used for wireless access to a carrier network (or as WLAN station) it serves as the DTE. Typically, in fixed wireless the computer uses a separate DCE (a transceiver) and local conduit to transmit over the antenna. From the antenna, transmissions travel to a carrier tower located at a POP (base station) where they enter a wireline or wireless carrier network (transport level). In a point-to-point system, transmissions do not require a carrier's transport network, since they are beamed directly to another antenna at another location of the business. In the point-to-point case, all equipment may be owned or leased by the agribusiness.

Another way wireless technologies differ from wireline is in the distinction between baseband and broadband. In wireless, baseband is the raw audio or video signal before modulation and broadcast. Thus, the original frequency range before modulation onto a higher, more efficient range is the baseband. For example, most satellite headend equipment uses baseband inputs. The input signal is unfiltered receiver output with FM modulated audio and data sub-carriers. Wireless broadband devices process a signal that spans a relatively broad range of input frequencies.

4.4.2 Terrestrial Wireless Technologies

As has already been mentioned, terrestrial wireless communication may be mobile or fixed. The first and second generations of wireless technology emphasized mobility and lower frequencies since they sought to provide only basic wireless telephony and low-speed data communications. The third generation saw mobile technologies operate in higher frequencies (such as the 2 GHz PCS band) while coverage zones expanded, power needs fell, data rates rose, and more services were supported. Simultaneously, third generation fixed technologies made dramatic leaps into upperband frequencies (24-39 GHz), attaining data rates as high as wireline technologies so as to support a range of hypercommunication services including voice, video, high-speed data and Internet.

In this section terrestrial (non-satellite) wireless technologies are briefly outlined. As with wireline technologies, almost every specific service named in sections 4.6 through 4.9 can be provided by terrestrial wireless technologies. The ability of terrestrial wireless technologies to serve as access paths for hypercommunication services depends mainly on signal frequency, user mobility, and the availability of appropriate antennas, DCE, and DTE. Table 4-10 details terrestrial wireless technologies used to support of mobile and nomadic services.

Typically, mobile user devices include DTE, DCE, and an antenna in a single unit. Mobile services are provided by carriers using a series of overlapping coverage zones (cells) each of which is served by a tower attached to base stations. As subscribers travel in their carrier's local footprint, calls are passed from one cell to another. Subscribers may roam regionally or nationally and use their own (or another) carrier's network if compatible technologies are available in the roamed area.

Mobile wireless voice services are discussed in more detail in 4.7.5, while paging is covered in 4.7.6. Mobile wireless data networking is covered in 4.8.5. Carriers extend service to subscribers based on one or more of the technologies shown in Table 4-10.

Table 4-10: Mobile terrestrial wireless technologies

Technology	Market Applications	Freq. & Channel Bandwidth	Data Rate
CDMA (Narrowband PCS)	Two-way paging, digital mobile enhanced telephony	900-941 MHz (25 MHz)	6.4-25.6 kbps
CSCD	Fax, file transfer, Internet	800 MHz Analog cellular (25 MHz)	1.2–9.6 kbps, 14.4 kbps optimally.
CDPD (Analog & early digital cellular overlay)	Two-way paging, POS, data queries, dispatch, on analog cellular line.	800 MHz (12.5-30 MHz)	4.8-12 kbps
Digital Cellular-PCS (IS-136 TDMA, IS-95 CDMA)	Two-way paging, fax, e-mail, enhanced digital telephony.	800,.900, 1900 MHz (25 MHz-200 MHz)	9.6–14.4 kbps (current), 1.2 Mbps (spread spectrum, future)
ARDIS (Motorola DataTAC)	Two-way paging, transportation data support, in-building wireless.	800 MHz (25 MHz)	2.4 kbps (nationwide), 9.6 kbps (limited)
BellSouth Wireless Data (Mobiltex)	Two-way paging, dispatch, database.	900 MHz (12.5 kHz)	4.8 kbps
AMPS cellular Telephone	Mobile telephony, modem applications.	400 MHz (25 MHz)	4.8-9.6 kbps. See also CDPD, CSCD
iDEN (SMR, ESMR)	Enhanced digital mobile telephony, Internet, e-mail, and dispatch.	800-960 MHz (15-30 MHz)	9.6 kbps-64 kbps (Nextel)
GSM-1900, TDMA (Broadband PCS)	Enhanced digital mobile telephony, file transfer, Internet, e-mail.	1.9–2.1 GHz (200 MHz)	300 kbps (extended range), up to 2 Mbps (local CZ)

Sources: FCC 99-136, Hewlett Packard, 1999, Rysavy, 1997, Weinhaus, 1998.

Table 4-11 lists several fixed wireless technologies that are currently or soon to be available in Florida. For each technology, the typical frequency and channel bandwidth, data rate, and services supported are shown. Since fixed terrestrial wireless technologies are works in progress, the table cannot convey more than a broad general categorization. Hence, the specific technologies listed in the table are often imprecise terms, based on a melding of traditional FCC definitions, proposed frequencies, experimental tests, and implementations by carriers.

Table 4-11: Terrestrial fixed wireless access technologies

Technology	Market	Typical Frequency (Channel Bandwidth)	Data Rate (Range)
WLAN via infrared	Segments of LANs.	3000-30000 GHz	4-16 Mbps (with token ring card (80 feet)
WLAN via laser	Local Area Network in office or campus.	30-150 THz (800 nm waves)	To 16 Mbps (3280 feet line-of-sight)
WLAN via RF	Local Area Network in office or campus.	5.1-5.8 GHz (30-100 MHz), unlicensed spread spectrum	10-100 Mbps (3280 feet in open, 650 feet in building)
2.4 GHz WCS	WWAN, WLAN, & Internet access.	2.402-2.48 GHz (1-25 MHz per channel), unlicensed spread spectrum	156 kbps to 11 Mbps (Up to 10-25 miles)
DEMS	Broadband microwave access: telephony, WAN, video, Internet.	24 GHz (100 MHz)	Up to 30 Mbps, (2-10 miles)
MMDS	Microwave access: telephony, data, video, Internet.	2-2.6 GHz (190-200 MHz)	Up to 10 Mbps (30-35 miles, one-way; 6 miles, two-way)
LMDS	Broadband microwave WAN & access: data, future telephony, video.	28 GHz, 38 GHz, (150 MHz, B Block, 1.15 GHz, A Block)	Downstream 20-50 Mbps, Upstream 3-10 Mbps, (3-5 miles, possibly 20)
WLL	Broadband microwave WAN & access: data, Internet, ATM, telephony, video.	39 GHz (100 MHz-1.4 GHz)	45-155 Mbps (2-5 miles, possibly 9-10)

Sources: REA (1992); Bezar (1995), Teligent (2000); Rysavy (1997); Molta and Irshad (1999), Mandl (1999).

The first fixed terrestrial wireless technologies are WLAN (Wireless LAN) technologies. The first type of WLAN is infrared WLAN. Infrared adapters plug into token ring cards to allow localized transmissions (within 80 feet). While infrared can be used between buildings, it is so susceptible to fog, rain, and smog interference (since it is a form of light) that it is usually used for remote controls, wireless keyboards, and wireless computer mice.

The last WAN technology includes the 5.8 GHz spread spectrum technologies that make use of unlicensed spectra to operate on a single premise. Spread spectrum technologies allow low-power operation and reduce interference. In open spaces, 100 Mbps ranges for wireless LANs (such as the Breeze Net Pro.11 product line) can range from 1000m (3280 feet) in open areas to 60-200m (200-650 feet) inside buildings.

WLANs use all-wireless Ethernet and specialized hybrid technologies. An all-wireless Ethernet LAN replaces cabling among computers in a local network with wireless paths, so individual computers require antennas to transmit to the network host. With all-wireless Ethernet technologies, laptop computers connect to the WLAN through antennas in their PCMIA slots and remain portable in the office. Hybrid WLAN technologies use wireline cabling to connect each machine in a particular area to a hub (or other intermediate DCE), but use wireless paths from hub to central server.

The second WLAN technology, WCS, may be particularly useful for agribusinesses seeking to interconnect LANs inside a ten to twenty-five mile radius of a central site (creating WWANs, Wireless WANs), or to obtain Internet access. The 2.4 GHz WCS band is also unlicensed spectrum that can be used on the local or access level. Since spectrum is unlicensed, the FCC requires that spread spectrum technologies be used that make radio signals appear as background noise to unintended receivers. Numerous service providers in many parts of Florida are currently offering wireless Internet access in the 2.4 GHz band. However, interference from garage door openers, baby monitors, and other wireless equipment can occur in the unlicensed frequencies used by WCS. Specific WLAN applications are covered in 4.8.5, while Internet access is the subject of 4.9.1.

DEMS is a two-way all digital system that uses DTSs (Digital Termination Systems) on each end as DCE. An important characteristic of DEMS is proper antenna placement [Weinhaus, Lagerwerff, and Brown, 1999]. User stations require directional antennas over a 2-10 mile long path length [REA, 1992]. In 1998, Teligent began to provide the first DEMS service in Florida to metro Jacksonville, Tampa, Orlando, Palm Beach County, and Miami-Dade County.

Teligent's DEMS technologies use a two-step wireless layout. In the first step, at the access level, "When a customer makes a telephone call or accesses the Internet, the voice, data or video signals travel over the building's internal wiring to the rooftop antenna. These signals are then digitized and transmitted to a 'base station' antenna on another building, usually less than three miles away." [Teligent, 2000] The DEMS base station functions as a POP for that area, gathering "signals from a cluster of surrounding customer buildings, aggregates the signals and then routes them to a broadband switching center." [Teligent, 2000]

LMDS and MMDS are similar in that both are multi-point microwave distribution technologies used to provide high-speed hypercommunications access. Both have been used to provide wireless cable TV, but new technologies allow two-way transmission. Some of the differences between LMDS and MMDS are frequency, bandwidth, and cell size:

> MMDS is authorized 190 MHz of spectrum near 2.5 GHz and LMDS is authorized over 1 GHz of spectrum near 28 GHz. MMDS architectures are designed for fairly large coverage zones, up to 50 km across. Typical MMDS reflector antennas are up to 0.6 m (2 ft) in diameter. LMDS, on the other hand, uses small cells and small antennas, with roughly 3- to 8-km coverage radius and 10 cm (4-in) flat panel subscriber antennas. [Vanderau, Matheson, and Haakinson, p. 19, 1998]

Designed as "wireless cable TV", downstream MMDS signals can cover up to a 35-mile radius. Hence, MMDS technology is expected to have a broader market than LMDS and more coverage of to rural areas. However, until now, upstream (symmetric) MMDS has been limited to a six-mile range. LMDS, with a 5-mile coverage zone, seems more suited to multi-tenant (office building) businesses in urbanized areas, though a network of LMDS transmitters can cover any area. MMDS is often seen as a SOHO (Small Office Home Office) technology if the technology can become more adept at achieving symmetric data rates over distance and at sharing scarce frequency [Roman, 2000]. Typical MMDS or LMDS CPE includes a roof-mounted transceiver and antenna, an up/down converter to change signal frequency to frequencies usable by DTE, an NIU (Network Interface Unit), possibly a telephone interface, and an Ethernet hub or router. The Sprint ION service is an example of an LMDS deployment that features downstream data rates of up to 27 Mbps, with a 3.5 Mbps upstream rate.

WLL is another upperband technology christened as fiber in the sky. Wireless POPs are centrally placed in urban areas with access accomplished via MTE (Multi-Tenant Environment, office building) rooftop transmitter to wireless hub paths. Estimates are that only three percent of office buildings have fiber, but that they represent one-third of all business communication lines [Mandl, 1999]. WLL is targeted at this three percent (the power users), while LMDS, MMDS, and to a lesser extent 2.4 GHz are aimed at the 97 percent without fiber access, the smaller business customer.

CDMA technology is used to economize on spectrum, so individual clients may maximize data rates. The 39 GHz band in which WLL will operate can carry data rates of up to 155 Mbps over several miles. Winstar is a WLL provider in Florida, with the right to provide coverage from Jacksonville to Miami along the Atlantic Coast and from Citrus County south to Everglades City on the Gulf Coast.

The new upperband technologies are no panacea for rural areas. According to the NTIA, most applications are for dense urban MTE locations.

> New and proposed terrestrial systems are being developed to exploit shorter range, cellular deployments able to serve a much denser subscriber base, using multipurpose digital bit streams. These emerging systems will need to be much smarter and more complex than traditional systems, and they will demand extensive infrastructure development and integration into existing telecommunication infrastructures. [Vanderau, Matheson, and Haakinson, p. 22, 1998]

Additionally, upperband technologies may not hold great promise for a high rainfall state such as Florida since the Southeast is the "worst area" for microwave signal propagation [REA, 1992, p. 1-9]

In spite of predictions by Gilder (1993) and others that wireless bandwidth would be boundless in 2000, *InfoWorld* has a different prediction for 2001. "Wireless users may hit a speed bump" because of limitations on spectrum and failure to deploy equipment in many areas [*InfoWorld*, October 29, 1999]. While terrestrial wireless technologies are developing slowly, inexpensive, symmetric satellite technologies are coming even more slowly.

4.4.3 Satellite Technology

Until fiber optics, satellite wireless appeared to have the most promise as a high-speed voice transport technology. Early 1960's satellites could carry 480 channels, compared with 256 then carried by telephone cable. By December 1988, TAT-1 the first fiber-optic transoceanic cable became operational and could carry 37,800 voice channels. By 1995, the TAT-12 and TAT-13 satellites (linking Europe and the US) could carry over one million telephone conversations at once [Stone, 1997]. At the end of 1997, over 180 communications satellites were in orbit, with industry sources expecting as many as 1700 additional satellites by 2005 [Rysavy, 1997]. It remains to be seen if future satellite technologies will carry many times this amount of converged voice and data traffic because of the high cost of orbital launches and the relatively high price of satellite DTE and DCE. However, satellite technology now holds promise in access, point-to-point, and transport levels for businesses regardless of location.

Orbital satellites use an uplink (earth-to-space) and a downlink (space-to-earth) to allow two-way communication. Special bands of the electromagnetic spectrum have been allocated for satellite use. Traditional satellite technologies use the C band and Ku bands. In the C band, 3.4-4.8 GHz is used for downlink and 5.85-7.1 GHz for uplink, while the Ku band uses uplink frequencies of 14-14.5 GHz with 10.7-12.2 GHz for the downlink. A new broadband Ka band of 19.7-20.2 GHz (downlink) and 28.35-28.6 GHz (uplink) is just beginning to see service.

Many satellite technologies are used to deliver wholesale services only to hypercommunication carriers. As with terrestrial wireless technologies, satellite services are classified as fixed or mobile. Fixed means that users on earth do not move, in contrast with mobile services where subscribers move. New technologies are under development by several large consortia to bring broadband (high-speed) services to individual businesses and wholesale customers. However, the costs of deployment and CPE are high enough that progress has been slow.

Table 4-12 shows several satellite technologies capable of providing both mobile and fixed hypercommunication services worldwide, now and in the future. Geostationary orbit (GSO) satellites and geosynchronous (GEO) satellites each orbit at altitudes of 22,300 miles (36,000 km) above the earth, revolving the earth once every 24 hours so they appear to be stationary. GSOs are GEOs that orbit directly above the equator. Geosynchronous satellites transmit both voice and data communications, but long delays are experienced. The delay arises from the fact that the uplink (earth to satellite) and downlink (satellite to earth) portion of the communication each travel at the speed of light. Each step results in a delay of a quarter of a second and up under the best circumstances [IEC, 1998, p. 19]. From three to five GSO satellites are deployed to get coverage of almost the entire globe. Larger constellations may be used to obtain faster data rates and greater overall capacity.

GSO technologies include GSO FSS (fixed satellite service) and GSO MSS (Mobile Satellite Service). GSO technologies have been implemented by several systems including Comsat (formerly part of AT&T), Intelsat, and Orion. However, ground equipment (CPE) at the businesses' location is extremely expensive and complicated at this stage. Hence, GSO technologies are normally used by large agribusinesses and other global organizations. Data or voice transmissions may be charged by the minute or by the kilobit.

Table 4-12: Mobile and fixed satellite technologies

Satellite System	Services Supported	Altitude (Speed)	Bandwidth (Data Rates)	Frequency	# to cover world
GSO	Voice transport, high-latency data. FSS & MSS	22,300 mi. (11,000 km/hour)	400 MHz -1.1 GHz (variable)	C band (4 GHz), Ku band	3-5
DBS (GEO)	TV, Internet	Same as GSO, but equatorial orbit	0.5 GHz (2 Mbps, downstream, 33.4 upstream)	12.2-12.7 GHz, 17.3-17.8GHz	3-5
MEO	Now: messaging, future: Internet, data networking.	6,250-12,500 mi. (19,000 km/hour)	500-800 MHz (9.6 kbps, 6 Mbps in future)	C band, Ka band (20 GHz)	10-12
Little LEO	Paging, GPS, remote monitoring.	400-1,000 mi. (27,000 km/hour)	25, 85 MHz (up), 25, 1900 MHz (down), (4.8 kbps)	137, 138, 399- 401 MHz	48-66
Big LEO	Satellite telephony, broadband PCS. Future: two-way data & Internet.	400-1,000 mi. (27,000 km/hour)	16.5 MHz (current: 400 kbps, down; 33.4 up via modem; future: 2 Mbps & 6 Mbps)	1-3 GHz (portions)	48-66
Broad-band LEO	Future access to Internet, WAN, converged networks.	150-400 mi. (27,000 km/hour)	.5-.8 GHz: (Future: 64 Mbps down, 2 Mbps up)	Ka band (20, 28 GHz)	200-288
Broad-band GSO & GEO FSS	Future access to Internet, WAN, converged networks.	22,300 mi. (11,000 km/hour)	.5-.8 GHz (Future: 500 kbps up, 3-6 Mbps down)	Ka band (20, 28 GHz)	8-20
MSS	Telephony.	GSO or NGSO	36-72 MHz	2 GHz	varies

Sources: Weinhaus, Lagerwerff, and Brown, 1999; Rysavy (1997); Hudgins-Bonafield (2000).

Advantages to GSO include worldwide coverage even of remote locations far from wireline connections. GSO technologies can also reach ships at sea (Inmarsat), airplanes, and every nation on earth with the satellite serving as access and transport level all in one. While the high latency of GSOs is annoying, echo cancellation and other innovations will improve the quality of GSO voice conversations. GSOs last an average of ten years before they must be replaced, double the length of the next type of satellite technology, NGSO [Hudgins-Bonafield, 2000].

There are several NGSO (Non-Geostationary Orbit) satellite technologies. However, by definition, continuous coverage of any single location on earth requires around the world coverage of similarly situated points. NGSO networks function in a similar way to terrestrial cellular networks in that each satellite has its own coverage zone within a network footprint. However, since the satellites are moving, coverage zones are moving as well whether the user is moving (NGSO MSS) or fixed (NGSO FSS).

DBS (Direct Broadcast Satellites) operate in the 12.2 to 12.7 GHz band (downlink, BSS) and the 17.3 to 17.8 GHz band (uplink, Feeder, FSS). Total bandwidth for uplink and downlink is 0.5 GHz [Weinhaus, 1998, p. 28]. DBS satellites are GEOs, so they exhibit high latency. Current systems such as Hughes' DirecPC offer Internet access with download rates of up to 2 Mbps, but require that the upstream end go through a normal telephone modem. Future iterations of DBS technologies are expected to allow a minimal wireless return path, though the emphasis of DBS is on the downstream rate.

MEOs are Middle Earth Orbit satellite systems. Their orbits are from 6,250 miles to over 12,000 miles above earth, in between the orbit of GSOs and LEOs. However, more satellites are needed in a MEO constellation than in GSO or GEO constellations. Between ten and twelve satellites or more are needed for global coverage by a MEO constellation. MEO technologies use up to 500-800 MHz channels in the C and Ka bands. MEO technologies support services ranging from simple messaging (9.6 kbps) to future rollouts of two-way Internet, voice and data networking with data rates of up to 6 Mbps expected. Because a single MEO satellite will be overhead any fixed site for only two to four hours before another orbiting satellite arrives, MEO technologies require coordination among satellites for uninterrupted coverage.

Another NGSO satellite technology is the LEO (Low Earth Orbit) satellite. These orbit from 150 to 1,000 miles above the earth, cutting down on the delay experienced with geosynchronous satellites. However, LEOs are costly to launch and operate because they require a constellation of satellites to cover the earth's surface. For example, the now bankrupt Iridium worldwide network was to have been composed of 66 satellites, while the Globalstar system will have 48.

LEO technology can provide point-to-point or person-to-person services to the entire globe except when atmospheric or solar conditions interfere. There is also significant risk of widespread system damage due to asteroids and meteorites that do not have the atmosphere to burn them up before they hit. LEOs travel at faster rates than MEOs or GSOs, adding to their risk of destruction. LEO construction costs of $6 billion and up per system have led to their development by international consortia, rather than any single firm. For example, (the now bankrupt) Iridium project had Qualcomm, Motorola, and Globalstar as partners.

There are two kinds of LEOs, big LEOs and little LEOs. Little LEOs are used primarily for paging, remote monitoring, vehicle tracking, and other GPS (Global Positioning System) applications. Little LEOs use frequencies from 137 to 400 MHz, offering bandwidths from 0.025 MHz to 0.85 MHz (downlink) and 0.15 MHz to 1.9 MHz uplink. Leo One and Orbcomm are two little LEO systems in common use. Little LEOs offer low-cost, low-speed transmissions of relatively small amounts of data worldwide with higher signal reliability than other space-based systems.

Big LEOs are intended to be the satellite equivalent of terrestrial cellular telephone service. Eventually, big LEO technologies will provide fixed and mobile voice, data, paging, and fax on a worldwide basis, even in rural areas and developing countries at limited data rates. Big LEO technologies use MSS frequencies between 1GHz and 3 GHz, generally around 1610-1625 MHz or 2483.5-2500 MHz, with a bandwidth of 16.5 MHz for each service link [Weisman, 1998, p.39].

Today, big LEO technologies support satellite telephony and broadband PCS. In the future, big LEOs will support two-way data & Internet. Today, Internet data rates from big LEOs are typically around 400 kbps with the return (upstream) signal traveling via wireline telephone modem. Future systems will attain data rates of from 2 Mbps to 6 Mbps. Big LEOs move across the sky quickly, rotating above a single point on earth as many as 14 times per day. Hence, the technology must be flexible enough to allow one satellite to take over from another when the line-of-sight from the first satellite becomes obstructed.

Another type of big LEO satellite technology is broadband LEO. Unlike typical big LEO (and other NGSO) technologies with broadband satellite technology, cells on earth remain fixed, while the network of satellites rotates around earth. The Teledesic satellite network (an NGSO FSS) will be a broadband LEO system capable of offering data rates of up to 64 Mbps (downlink) and 2 Mbps and above (uplink), operating in the Ka band (20 GHz to 30 GHz). Service is anticipated to start in 2004. Broadband LEO systems are seen as an "Internet in the Sky", linking computers worldwide with high-speed connections. The bandwidth of service allocations is 0.5 GHz, with feeder allocations of 0.8GHz. Since they orbit between 150 and 400 miles above earth, broadband LEOs may be over a particular location on earth for only tens of seconds before a new satellite must take over. While broadband LEO technology is engineered to accomplish this, the degree of jitter depends on the total number of satellites in a carrier's constellation [Hudgins-Bonafield, 2000]

Teledesic is an example of an NGSO FSS system, while thirteen GSO FSS systems have been authorized by the FCC including Loral, PanAm Sat, and KaStar [Weinhaus, Lagerwerff, and Brown, 1999, p. 32]. Broadband GSO and GEO satellites have higher delays than LEO or MEO, but lower jitter because there is less variability due to handoffs from orbital changes. Both types of broadband FSS operate with channel bandwidths of 500-800 MHz, Future broadband LEOs are expected to feature data rates of up to 64 Mbps downstream with 2 Mbps upstream rates. Broadband GSOs use the same frequencies and bandwidths, but are expected to achieve upload speeds of 500 kbps with 3-6 Mbps download speeds [Hudgins-Bonafield, 2000]

Mobile Satellite Service (MSS) technologies operate near 2GHz, offering a total bandwidth of from 35-72 MHz for uplink and downlink. MSS can be provided by GSO or NGSO technologies. MSS technologies were originated by INMARSAT to enable communication with ships on the high seas [Telecommunications Engineering Centre, 2000]

Advantages of satellite technologies include their lower susceptibility to multi-path fading caused by reflection from objections surrounding the transceiver on the ground [NRC, 1997].By beaming signals vertically, upperband signals show considerably less attenuation than when transmitted terrestrially. They also offer worldwide coverage to rural areas as well as urban ones. It remains to be seen which satellite technologies offer agribusinesses the greatest promise for future hypercommunication needs. For agribusinesses with a need to network directly with rural, third world operations, or foreign customers, satellite technologies may be the only possibility for years to come.

An important physical limitation to satellite technologies is the high path loss. The higher the operating frequency, and the greater the path distance, the more transmit power is needed to compensate. Satellite signals are attenuated by earth's atmosphere and by cosmic and solar noise. The NRC reports that while satellites offer advantages over horizontal fixed wireless transmission, adverse effects still occur "at frequencies above 10 GHz, where oxygen and water vapor, rain, clouds, fog and scintillation cause random variation in signal amplitude, phase, polarization, and angle of arrival . . . " [NRC, 1997, p. 2-6] High-gain directional antennas help reduce upperband problems, but such high frequency digital transmissions are troublesome given Florida's climate. High deployment costs are another disadvantage of satellite technologies, with costs of devices and carrier equipment comparatively large.

4.4.4 Wireless QOS

As shown in Table 4-13, QOS in the wireless environment has more variability than in the wireline case. While new wireless technologies are constantly appearing to counteract QOS problems, wireless paths are subject to interference from man and nature. Satellite and mobile services have the more difficulty in establishing guarantees comparable to wireline carriers.

Table 4-13: QOS dimensions and wireless.

Dimension	Description	Wireless difference from wireline
Bandwidth	Maximum capacity of path	Bandwidth is a more theoretical concept since capacity varies by path loss, multi-path fading, etc.
Throughput	Transfer speed noticed by users.	Higher error rate, larger jitter, and reception variability can slow throughput.
Bit rate	Variable operational speeds of DCE.	Wireless devices must be flexible enough to adapt to many possible speeds even when multi-path fading causes rapid variations.
Data rate	Actual speed of path.	Larger observed variance. Since error rate is higher, data rates (which are error-free) are affected.
End-to-End delay (latency)	Time a bit takes to go from sender to receiver.	Higher at greater distance (satellite), errors, conversion & encryption increase delay.
Jitter	Variation in delay.	Likely to be much larger.
Connection establishment delay	Time it takes for connection to establish.	Establishment of radio path may take longer with some services, greater variability than in wireline connections.
Connection establishment failure probability	Probability that a given attempt will not establish path.	Chance that sender or receiver cannot establish connection (due to noise, interference, etc.). Most likely for mobile & nomadic wireless.
Network transit delay	Time from transport sender to receiver. (Transport & Access)	As with wireline, varies depending on network load, management. Frequency sharing technologies lower this, but other factors increase it.
Error rate	Fraction of lost or garbled messages in a period.	Interference, loss, fading may cause this to be higher than in wireline. Possibly transparent to user due to slower data rate and throughput.
Security	Ability of others to intercept or copy messages or gain network access.	Inherently easier to eavesdrop on wireless conversations unless scrambling or other techniques are used. Data require encryption, slowing throughput.
Priority classification availability	Ability to create traffic priorities.	No difference.
Resilience	Chance of spontaneous failure at any level.	Wireless equipment is exposed to lightning and weather & has been less thoroughly tested than wireline.
Environmental specifications & safeguards	Effect of power failures, lightning, etc. on communication.	Thunderstorms, solar flares, & even fog can lower data rate or cause the complete interruption of wireless signals.
Overall failure probability	Fraction of time when any QOS dimension fails to reach standard.	The probability of at least one QOS metric being violated is unambiguously higher.

Sources: NRC, 1997; FitzGerald and Dennis, 1999.

There are several physical reasons wireless has QOS disadvantages: frequency, channel width, various kinds of interference, latency, jitter, and tighter technical specifications. As has been mentioned repeatedly, higher frequencies tend to have wider channel capabilities and hence, more bandwidth. This comes at the cost of shorter radio waves that can travel shorter distances, are more prone to interference, and may have negative health consequences. Interference, fading, path loss, and attenuation vary by technology, frequency, and location.

Even with fixed wireless technologies, there is more signal variability than with wireline transmission, propelling error rates higher. Latency and jitter interact with effective bandwidth, data rate, and error rate. Latency or delay depends on distance. Thus, GSO and GEO technologies are most affected followed by MEO and then LEO. All satellite technologies are affected more by delay than earth-based wireless technologies are. Finally, tight technical specifications such as antenna angles, humidity ranges, and antenna type can make wireless services hard to deploy without specially trained carrier and agribusiness personnel.

With few exceptions, wireless QOS is less controllable than wireline. Hence, it may be hard for agribusinesses to gain SLAs (guarantees of service) from wireless providers on par with wireline carriers. Next, the technologies and people needed to operate and interconnect hypercommunication networks are covered.

4.5 Support Services, Facilitation, and Consolidation Technologies

Support services, facilitation, and consolidation technologies cover a wide territory and there is only space to touch on a bare minimum. Support services (4.5.1) include the human expertise necessary to install, maintain, interconnect, and otherwise assist users and suppliers of hypercommunication technologies and services. Protocols and standards (4.5.2) are the building blocks necessary to improve hypercommunication markets and enable convergence, deregulation, and interconnection. Protocols, standards, and the various standards organizations are hypercommunication facilitation technologies because they create better markets.

Consolidation technologies are known as convergence-enabling technologies[28] since they are examples of areas where convergence will occur. The first consolidation technologies to be covered are wireline-wireless facilitating technologies (4.5.3). Voice-data consolidation technologies (a second type of consolidation technology) are covered in 4.5.4. As both kinds of consolidation technologies become more widely used by agribusinesses, true converged hypercommunication will occur.

Separating support services, facilitation technologies, and consolidation technologies from the services and technologies of specific sub-markets is somewhat artificial. Later, these three subjects are placed in the context of the specific sub-market for specific services and technologies (4.6-4.9). There is an historical component to the separation in that support services are necessary now, facilitation technologies are under constant development, and consolidation technologies are a promising area for the future. However, by separating support, facilitation, and consolidation, agribusinesses will better understand where they will have to invest money, what differences exist among carriers, and where convergence will come from.

4.5.1 Support Services

The dollar cost to business of support services, the human side of hypercommunications, will reach twice the level of equipment costs by 2003. Business expenditures on services to support voice and data equipment are projected to grow at an annualized compound rate of 19.5 percent through 2003 to reach $237.1 billion, more than double the projected $112.6 billion equipment market for 2003 [TIA-MMTA, 2000, p.94]. Costs for support and integration services of voice-data communications equipment stood at $116.4 billion in 1999. There are two fast-growing categories of support services.

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[28] Consolidation technologies bring about what are called convergent solutions (data and voice over the same pipeline and DCE to the same DTE).

The first support service category is professional and technical services. This area includes network integration services, consulting, and time and materials for engineers, computer scientists and programmers, and other professionals. In 1999, professional and technical services represented $73.8 billion of the total support service bill for American enterprise. The tab is only expected to grow larger. The second support services category are field maintenance and repair services. In 1999, expenditures here stood at $31.1 billion, with the expectation that the level will continue to rise.

Support services tend to be specific to the services and technologies they support. Thus, some additional coverage occurs in the context of the sub-markets discussed in sections 4.6 through 4.9. Agribusinesses should realize that their CPE and the equipment of their carrier are only as good as the people who service it at the carrier end and the people who use and maintain it at the agribusiness. Furthermore, having employees or consultants whose judgement can be trusted is vital to choosing the right equipment to begin with.

4.5.2 Protocols and Standards for Hypercommunications Networking

Protocols such as (TCP/IP, SS7 signaling, and V.90) may be created through scientific agreement or by government, self-regulatory or independent bodies. Hypercommunications protocols and standards help consumers and suppliers avoid the deadweight loss of endlessly searching technical specifications or creating new ones by establishing mutually agreed upon definitions, along with interoperability and interconnection of technologies and services. This sub-section has three main purposes. First, to classify and explain the sources, bodies, and technical types of standards and protocols. Second, to place hypercommunication standards and protocols in an economic context of interest to agribusinesses. Third, the section outlines a couple of strategic areas where protocols and standards have not yet been agreed upon, placing emphasis on their importance in business settings.

The term protocol is often used interchangeably with standard. According to the FCC, protocol and standard have two separate meanings each. First, protocols are "a formal set of conventions governing the format and control among communicating functioning units". Second, protocols are also "a formal set of procedures that are adopted to facilitate functional interoperation within" a "layered hierarchy" [GSA, *FED-STD-1037C*, 1996, p. P-25]. The IP (Internet Protocol) is one of the better known examples, underscoring the tendency for protocols to be used in communications networking software and hardware.

Standards are "guideline documentation that reflects agreement on products, practices, or operations." [GSA, *FED-STD-1037C*, 1996, p. S-26] A second definition of standard as "a fixed quantity or quality" is frequently used [GSA, *FED-STD-1037C*, 1996, p. S-26]. A standard is more likely than a protocol to describe hardware (e.g. wiring standards) or to characterize physical quantities such as specification ranges (e.g. engineering operational standards). While the two terms are used almost interchangeably in this section, precise meanings (when important) should be clear in context.

Economist Paul David established three classes of standards [David, 1987] that some authors consider the "best classification system for telecommunications (standards)" [Stone, 1997, p. 122]. Reference standards deal with weights, measures, and other units. These tend to be agreed on by international standards bodies and are generally objective, scientific-based standards. Minimum attribute standards are the minimum acceptable characteristics associated with the deployment of a hardware or software technology. Compatibility standards permit interconnection of CPE and other hypercommunications components such as hardware and software to work in conjunction with an entire network or system.

To these three, security standards could be added. These are standards designed to prevent access to certain information due to privacy, or the desire to sell intellectual property such as hardware, software, or content. Authentication CGI scripts, e-commerce software (such as shopping carts) and hardware (such as secure servers) are common Internet examples. Other computer examples are virus blockers, cookies, automatic registration and upgrading of browser plug-ins, un-uninstallable programs, etc. A particularly controversial case involves cryptography, where e-mail and other communications traffic are sent in coded form that only can be understood with a key at the other end. Federal law enforcement and national security reasons have been given to prevent the export of certain kinds of cryptography software [*Internet Week*, June, 15, 1998, p.1].

When IAB (Internet Architecture Board) protocols advance to become draft standards, the technical community is on notice that "unless major objections are raised or flaws are discovered, the protocol is likely to be advanced to a standard in six months" [IAB, 1995, p. 2]. Protocols and standards have both a state and a status. The state shows at what stage of the standards track (maturity level) a particular protocol has attained. For example, a new protocol occurs after an RFC (Request for Comment) has been issued. In an RFC, users and scientists are asked to comment on a particular proposed protocol. Then, after debate and dialog, that proposed protocol becomes a draft standard, then a required or recommended standard.

Protocols and standards may come from several sources, both formal and informal. There are formal *de jure* standards and protocols, created and altered by official trade, governmental, or scientific standard setting bodies. In some cases, these formal standards and protocols lag behind technology, while in others they lead technology. In still other cases, *de jure* protocols and standards describe technologies not yet introduced (and possibly never marketable). Due to the cumbersome process of adopting or altering standards (by international committee), *de jure* standards are notorious for being time consuming.

De facto standards and protocols arise from informal sources such as the marketplace or a single vendor [Tower, 1999]. For example, Microsoft developed MS-DOS, Windows 95, Windows 98, Windows 2000, and NT as *de facto*, proprietary operating system standards. When the marketplace adopted Windows as a *de facto* OS standard, it got built-in data communications protocols also developed by Microsoft. Windows data communications protocols are a mix between open, *de jure* protocols such as IP and TCP and proprietary, *de facto* protocols such as NetBEUI and Microsoft Front Page extension web hosting. In some cases, *de facto* standards and protocols become *de jure* when formal sources adopt them. The *de jure* adoption (or non-adoption) of *de facto* standards may occur due to market power and/or technical reasons. A central tenant of network economics is that networks rely on protocols and standards to operate. This reliance is so great that path dependencies occur (see Chapter 3.6) so the economy can veer off an optimal path [Kelly, 1998]

Several examples illustrate the importance of standards. The first two examples concern how changes in standards can completely change the market. The FCC changed FM frequencies in 1945, making FM radio receivers built before then obsolete. Another example came in when a 1963 law mandated that all television sets be equipped with both VHF and UHF channels. In both cases, a change in *de jure* standards made existing equipment obsolete. The relatively recent struggle to create a *de jure* 56 kbps modem standard (V.90) from two incompatible *de facto*, proprietary standards (x2 and K56 Flex) is a further example. In the 56k case, a standard was agreed on that allowed both proprietary technologies to continue under a single unified standard.

Protocols and standards are often behind the confusion between services and technologies. The source of confusion is rooted in data communications according to Klessig and Tesnick:

> This must be related to the data aspect since no such confusion exists for voice services. No one chooses their interexchange telephone service provider based on the protocols used to control the carrier's telephone switches. [Klessig and Tesnick, 1995, p.1]

Protocols have already enabled the telephone, telegraph, television, and radio sub-markets to exist and thrive. They are necessary to fuel continued growth in newer spheres such as Internet access, wireless technologies, and e-commerce services, if they can be agreed to quickly.

There are several kinds of standards organizations. The first is the independent testing organization. Underwriter's Laboratories, Inc. (UL) is an example. These organizations charge vendors a fee to test and certify the safety and sometimes the efficacy of equipment such as conduit and hardware devices. Another kind includes governmental agencies. The FCC imposes *de jure* standards on communications equipment to prevent interference with other communications and to ensure that connection of a DCE or DTE to a network (either CPE or carrier) does not harm other devices. For example, download speeds of certain 56k modems are restricted to 53 kbps because of FCC regulations designed to prevent excessive power from damaging elements of the telephone network. The third kind of standards organization is the independent national or international *de jure* standards body. A fourth kind is the scientific society.

In the United States, ANSI (American National Standards Institute) is a membership-supported, non-profit organization founded in 1918 by several engineering societies and US government agencies. ANSI does not develop standards itself, but encourages their development by coordinating communication among stakeholders (qualified engineers, government agencies, and others). ANSI is a member of the ISO (International Standards Organization), an international *de jure* body. The ISO is an organization similar to the United Nations. The ISO developed the seven layer OSI model discussed in Chapter 3.

Historically wireless standards evolved from the CCIR (International Radio Consultative Committee) which became the first international standards organization in 1927. The 1932 Conference of Madrid replaced CCIR by establishing the ITU (International telecommunications Union), the international body with jurisdiction over communications. ITU became a UN agency after World War II. IFRB (International Frequency Review Board) was part of ITU, until spectrum technologies and use required a new body, the CCITT (International Telephone and Telegraph Consultative Committee), formed in 1956. Intelsat (International Telecommunications Satellite Organization) was formed in 1964 after the U.S. created Comsat (Communications Satellite Corporation).

Many wireline standards and protocols also come from the ITU, which includes representatives from government, telecommunication companies, and industry organizations. Wireline standards include SS7 (Signaling System 7), established by the ITU, RJ-11 telephone cable (ITU), and numerous standards and protocols developed by AT&T's Bell Labs (now part of Lucent), and the RBOC (Regional Bell Operating Companies) successor to Bell Labs, Bellcore, now Telcordia.

Data communication standards and protocols form the basis of hypercommunication networks today. The IEEE (Institute of Electrical and Electronic Engineers) is behind many data communication protocols and standards in the physical and data link layers. IEEE standards include RJ-45 Category 5 cable jacks and Category 5 cable. Other IEEE standards and protocols are numbered such as 802.3 (10 Mbps Ethernet), 802.5 (token ring), and 802.11 (wireless LANs).

The IETF (Internet Engineering Task Force) is the main Internet standard and protocol body. The IETF sets up working groups (whose members are selected from thousands of Internet firms and organizations) to establish proposed standards for the Internet that are then voted on. The IETF established HTTP (web transport), POP (e-mail Post Office Protocol), and TCP/IP (Internet network layer protocols). The idea for TCP came from Vinton Cerf and Bob Kahn's 1974 paper, "A Protocol for Packet Network Intercommunication" [Zakon, 1997, p. 3]. TCP and IP together became the protocol of choice for ARPANet (the U.S. DOD precursor of the Internet) in 1982.

Table 4-14 provides an overview of some common interconnection, interoperability, and privacy protocols. For each standard or protocol, the standards body, purpose, and major users are listed. The first of these, SS7 plays an important role in services provided by ILECs and ALECs such as ISDN and advanced telephony. SS7 allows fast call setup and remote database interactions. Without SS7, there would be no "portable" 800 numbers, cellular roaming, caller ID, Enhanced 911, Custom Local Area Signaling System (C/LASS), or Advanced Intelligent

Networks (AINs) across CO networks. SS7 is "out of band" signaling, freeing circuits of overhead and extending capacity [Nortel, 1997]

TCP/IP is the main communications protocol of the Internet. The higher-layer, TCP (Transport Control Protocol) divides files (e-mail, HTML, graphic, URL request, etc.) into efficiently sized packets for routing over the Internet. Each packet has the IP address of the destination and can travel a different route to reach that point. Upon receipt at the other end, TCP reconstitutes the file in the correct order. TCP-based protocols include Ping, Telnet, FTP, and HTTP. The lower-layer IP handles the addresses of each packet.

HTTP (HyperText Transfer Protocol) and POP (Post Office Protocol) are widely used in Internet communications. ATM (Asynchronous Transfer Mode) is an increasingly used high-speed transport (and now access) technology to be covered in 4.8. The V.90 modem standard came from a compromise between the K56flex (Rockwell) and x2 (US Robotics/3Com) proprietary standards. HTML is the standard way static web pages are created. Frame relay (covered in 4.8) is used for WAN and Internet access by medium-sized firms provided over copper.

The S.100 interface was created to speed the convergence of voice and data. DSVD is a proprietary standard created by Rockwell and several other companies to allow modem users to remain online while receiving or making telephone calls. SSL (Secure Sockets Layer) is a method of guarding the security of online transactions. CDPD (Cellular Digital Packet Data) is one of several standards created to allow data transmissions over wireless (in this case cellular) connections. H.320 is an umbrella standard that covers the transmission of video over digital connections, such as the Internet.

Protocols and standards provide an important economic benefit: they help to prevent market failure. This is because some degree of uniformity or standardization tends to help markets perform better by accelerating adoption of new technology. This accelerated adoption occurs as compatible DTE, DCE, hardware, and software are purchased by the market.

Table 4-14: Important standards and protocols.

Protocol or standard	Body	Purpose	Major Users
Operating Systems (MS-DOS, Windows 3.1, 95 & 98	Private (Micro soft)	Allows computers to operate & software to work on particular computer platforms.	Computer users & software designers.
SS7 telecommunications protocol	ITU	Provides 800 numbers, caller ID, other custom calling services, increases existing transport level capacity.	Network engineers, affects telephone customers.
TCP/IP	IETF	Internet communications protocols. TCP divides files into packets, sends packets to an IP address, then reconstitutes packets into files.	Internet, Intranet, & Extranet users.
HTTP	IETF	Translates alphanumeric WWW addresses to numeric IP addresses.	Web users.
POP	IETF	Protocol for e-mail.	E-mail users.
ATM	ITU	High-speed form of TDM used to send 53-byte information cells (voice, video, data).	Network managers, large businesses.
V.90 Modem Standard	ITU	Allows 56 kbps download over analog telephone lines.	56 k modem owners.
HTML	W3C	Enables creation of hypertext (web pages).	Web designers.
Frame relay	ANSI, CCITT	Data networking & Internet access. Data-link layer fast-packet technology that transmits a set of data packets (frames) in bursts.	Network managers, small & medium businesses.
S.100 interface	ECTF	Allows convergence of telephones and computers.	Expected to see use in converged business networks.
DSVD	Private (Rock-well)	Allow modem users to answer telephone lines, access caller ID, send faxes, etc. while remaining online.	SOHO.
SSL	IETF	Makes e-commerce transactions more secure.	E-commerce website customers.
CDPD	ISO	Allows data to be sent over cellular connections.	Second generation cellphone data users.
H.320	ITU	Umbrella standard for video compression	Used in many web applications.

However, in some ways, standards may cause market failure. In the computer networking business standards bodies are manipulated by firms with market power as Saunders points out:

> The real reason net managers have so many high-speed LAN standards to choose from has little to do with their best interests and a lot to do with the self-interests of the vendors that manufacture and market network gear.

> Equipment makers are under the gun to deliver products that conform to industry standards --- any standards. Standards-based products sell better than proprietary offerings; in fact, some venture capitalists are making standardization a condition of further investment in networking companies. Most companies in the networking business are tiny by today's global business standards, which means they can't afford to ignore demands by potential investors.
>
> Rather than pool their efforts into creating a single set of standards, vendors have pushed hard to get their various technologies stamped with an ANSI or IEEE seal of approval---a procedure that has proved ludicrously easy since standards committees are made up almost exclusively of vendor representatives. This approach may legitimize competing technologies, but it can only spell trouble for network managers, who lack an official ombudsman to voice their opinions and concerns. [Saunders, 1996, p. xvii]

In addition to the tendency for standards to serve as mechanisms for maintaining market share, many standards bodies have been criticized because of the lack of open debate and user access to existing and proposed standards. The Internet has tended to have a more open approach to standards that has less chance of being captured by powerful industry forces than the telephony or data networking areas. For convergence to occur, both the gap between wireline and wireless and the chasm between voice and data must be bridged. The hypercommunications market is attempting to standardize convergence through wireline-wireless facilitating technologies (4.5.3) and voice-data consolidation technologies (4.5.4).

4.5.3 Wireline-Wireless Facilitation Technologies

Technologies used to facilitate hypercommunications between wireless and wireline networks are of two types: PSTN-based and data synchronization. For services that rely on connection to the PSTN, protocols and standards exist to interconnect wireless and wireline networks. These protocols and standards came about based on the desirability of having mobile telephone units able to connect with any other telephone (mobile or wireline) in the world. Since the wireline PSTN was in existence before cellular, PCS, GSM, and other mobile wireless devices were, it was necessary only to connect base stations that received and sent wireless signals to wireline PSTN. Cellular and other mobile wireless carriers also established standards for data transmission using wireless modems so data communications could occur between wireless networks and data networks connected to the PSTN.

One open, wireless-wireline facilitation technology is CDPD (Cellular Digital Packet Data). CDPD was created to "address the need of subscribers to be able to rapidly transmit a small amount of data and not tie up a cellular radio channel for a long period of time" [Harte, Prokup, and Levine, 1996, p. 376]. In 1995, 12,000 cell sites had CDPD capability [Harte, Prokup, and Levine, 1996, p. 377]. By 2000, CDPD was available in every major urban area of Florida.

Another PSTN-wireless facilitation technology is the proprietary iDEN™ (Integrated Dispatch Enhanced Network) standard, an exclusively digital TDMA system, formerly known as MIRS (Motorola Integrated Radio System). Typically used in 800 MHz SMR (Specialized Mobile Radio), MIRS was developed for FleetCall, now Nextel, which had radio coverage of almost all of North America by 1995. Recent iDEN™ technologies allow up to 64 kbps of data on a single 25 MHz radio channel and the simultaneous combination of data and voice. This technology allows both voice and data calls via the PSTN, as well as radio voice and data communications to a private network [Harte, Prokup, and Levine, 1996]. In 2000, Nextel's Florida network covers Tallahassee, Jacksonville, Miami, Palm Beach, Tampa, Orlando, and other urban parts of Florida.

The second type of wireline-wireless facilitation technologies involves device and data network synchronization. Here, the protocols allow wireless and wireline computers, laptops, PDAs (Personal Digital Assistants), mobile telephones, and other devices to synchronize data files and data communication among devices. There are several standards being developed by industry groups, most notably the SyncML Initiative. SyncML is being developed by IBM, Lotus, Motorola, Nokia, Palm Inc., and over 800 other firms. The idea behind SyncML is that networked data on mobile wireless devices needs to be as closely updated (synchronized) as possible with corresponding data on both nearby and remote wireline networks [SyncML, 1999]. Thus, for example, a salesperson's laptop computer would be immediately updated with an inventory change even if the computer were away from the home office. Similarly, if an order were placed at a customer's office, the salesperson would not have to return to company offices or dial-in by modem to place it. SyncML is still being established, but it has great promise for agribusinesses.

Another kind of wireline-wireless facilitation technologies are Bluetooth technologies. Like SyncML, Bluetooth technologies operate with both wireless and wireline equipment. However, Bluetooth technology is meant to facilitate the complete interconnection of fixed and nomadic (rather than mobile) wireless equipment with wireline and wireless devices on a short range, low power basis only. Bluetooth is a consortium led by Ericsson, IBM, Intel, Nokia, and Toshiba charged with designing internetworking standards for all kinds of wireless (and some wireline) devices. Wireless devices will interconnect with each another (and to a main wireline network) at data rates of up to 725 kbps over ranges of up to thirty feet [*InfoWorld*, 21(33): August 16, 1999]. The market research firm Dataquest estimates that by 2002, 79 percent of digital handsets (and hundreds of millions of PCs) will be Bluetooth-capable.

4.5.4 Voice-Data Consolidation Technologies

Voice-data consolidation technologies support what are variously known as convergent solutions, unified messaging, and FSN (Full-Service Networks). The idea is either to merge voice and data pipelines or converge voice and data DCE or DTE (or both). Voice-data consolidation is already a reality at the transport level, with a data-centric definition of voice expected to predominate. Half of BellSouth's transport network traffic is already data, with the expectation that by the year 2008 less than ten percent will be traditionally defined voice [Ackerman, 1999].

The technologies and economies of scale that are behind consolidation at the transport and access levels are now becoming achievable through new technologies in local networks for small agribusinesses. Voice and data traffic may be merged throughout an agribusiness' operation, only on the carrier side of the demarcation line, or both. While still a relatively new area of technology, voice-data consolidation technologies include advanced call center technologies, CT (computer telephony), VOIP (Voice over IP), VOF (Voice over frame relay), interactive voice, and voice processing equipment.

The ECTF (Enterprise Computer Telephony Forum) is a standards body specifically dedicated to creating interoperability agreements among the hundreds of telephone equipment, PBX, and computer software vendors [ECTF, 1997]. The ECTF is charged with developing APIs (Application Program Interfaces) to allow desktop computers, network clients, and host computers to control incoming and outgoing telephone business calls. The technologies involved include: voice compression/expansion, text-to-speech, voice recognition, fax, fax-to-text, desktop telephony, screen telephones, and hearing impaired devices [ECTF, 1997, p. 6]. The essence of ECTF voice-data consolidation technologies is that all hardware, software, DTE, and DCE within a business would be fully interconnected and interoperable.

An important voice-data consolidation technology is CTI (Computer Telephony Integration). CTI was the fastest-growing category of business telecommunications equipment achieving a 67 percent increase in spending from 1998-1999 [TIA-MMTA, 2000]. CTI is a collection of applications that go beyond the familiar automated attendants, (ACD, Automated Call Distribution), and IVR (Interactive Voice Response) systems that prompt telephone callers for an account number or use speech recognition to connect calls. CTI includes the recording, storing, forwarding, and broadcasting of voice mail, fax-on-demand, automated outbound dialing for telemarketing offices, and inbound "screen pop" applications that enable businesses to pull up a customer's record on the computer screen as calls come in.

CTI requires new hardware, software, and standards to realize convergence of telephone and computer networks. CTI is not new having been introduced to large catalog sales, telemarketing, and other firms in the early 1990's. However, new CTI technologies make CTI affordable even for small businesses, while previously proprietary devices such as PBXs and telephone sets are able to work with computers in novel ways. Two examples merit brief attention.

MVIP (Multi-Vendor Integration Protocol) is an open, *de facto* standard begun in 1990 that creates a multiplexed digital telephony highway inside a business controlled in one computer chassis, the communications server. MVIP standardizes connection of digital telephone traffic between individual circuit boards so that telephone conversations can be manipulated like any other kind of computer data [GO-MVIP, 1999]. MVIP supports telephone switching using digital switch elements inside the circuit boards of normal PCs. MVIP software standards allow a range of compatible products from compliant vendors worldwide to be used. CTI applications supported by MVIP include call management, fax, voice (live, stored and forwarded), text-to-speech, speech recognition, data and Internet communication, along with digital circuit switching.

The objective of an MVIP bus is to carry telephone traffic. It allows the telephone network connection to be separate from digital voice processing resources, so the telephone connection or PBX may be obtained from one vendor while the voice processing resources are obtained from others, saving businesses money. A single MVIP-90 bus has the capacity of 256 full-duplex telephone channels [EAGLES, 1997, Node 80]

Another *de facto* voice-data consolidation technology is SCSA™ (Signal Computing System Architecture). Dialogic (a division of Intel) announced the SCSA™ initiative in 1993 along with several dozen other computer telephony vendors. Like MVIP, SCSA™ is a telephony bus. However, SCSA™ can "interface to the public network or the PBX, perform a variety of voice-processing functions, recognize DTMF digits, and then initiate an outgoing call or switch to additional resources (e.g., fax-on-demand service, voice recognition, or text-to-speech)." [*Byte Magazine*, November, 1996].

According to Dialogic, SCSA™ is a high level call processing architecture with a holistic, multi-layered hardware and software foundation so firms can build call processing systems using standard interfaces but select from a variety of competing technologies. SCSA™ is an open, hardware-independent, software-independent architecture with the objective of providing standards that allow portability, scalability, and interoperability with different software applications [Dialogic, 1997]. An SCSA™ bus has a capacity of 2048 time slots (for a PC) on its bus called Signal Computing Bus so that CT hardware from many manufacturers can be run on a single communications server [EAGLES, 1997].

Taken together, MVIP and SCSA™ are examples of consolidation technologies that are enabling convergence, removing market power of equipment makers, and lowering acquisition costs and recurring expenses of hypercommunications CPE. These and other consolidation technologies are discussed in 4.7.1 and 4.7.2 when enhanced telecommunications CPE and CTI services are covered.

4.5.5 Preface to Specific Sub-Markets: (Sections 4.6 through 4.9)

In sections 4.3 through 4.5, several broad areas of hypercommunication technologies were considered. Before becoming more acquainted with the sub-markets for specific services and technologies, it is important to reiterate that there can be a difference between a service and a technology. According to Dan Lynch in the foreword to Klessig and Tesnick:

> They (the authors) point out emphatically the difference between a 'service' offering and a 'technology' offering. Thus, they explain what is different about SMDS and ISDN, frame relay, ATM, and SONET: SMDS is what the customer 'sees'; the others are technologies that the carriers use to deliver the services… [Klessig and Tesnick, 1995, p. vi]

This confusion between services and technologies becomes worse as converging delivery technologies blur the traditional distinction between voice and data. Indeed in the short time that has passed since 1995, new technologies and new services have been developed that make distinction more difficult. In some cases particular services and technologies were synonymous and are not now, while in others the distinction is historical. Furthermore, it is often easier to sell agribusinesses something new and complex when carriers use an existing concept, even if it brings a completely new meaning.

The next sections (4.6 through 4.9) cover four specific hypercommunication sub-markets, summarized in the services-market matrix found in Table 4-15. Many services can be provided by multiple markets *and* multiple transmission technologies (or protocols) covered in 4.3 through 4.5. For example, a local telephone call (a specific service) can be made within three sub-markets: traditional telephony, enhanced telecommunications, and Internet. Physical access to each of these markets may be wireless or wireline.

The first sub-market is traditional telephony services (4.6) such as local and long-distance telephone coupled with related enabling technologies (switches, trunks, and telephone sets). The second sub-market is enhanced telecommunications services (4.7), which include caller ID, CTI services, digital PCS, dedicated circuits, and circuit-switched services. Also given brief coverage are software and hardware technologies (AIN, DMS-100 switching, and SS7 signaling) that enable the enhanced sub-market. The third sub-market, private data networking services (4.8) includes packet and cell-switched services and specific supporting technologies. The fourth sub-market, which includes Internet services (from e-mail to web design), is explored in 4.9.

The row elements of the matrix are specific services an agribusiness might need, while the columns show the sub-markets capable of delivering those services. The sub-markets shown are already collapsing into a single hypercommunication market as convergence occurs. The separation of sub-markets simply demonstrates current market definition and structure. Of course, the expected result of convergence will be a hypercommunication market with an entirely different market structure with profound implications for agribusinesses.

Table 4-15: Services-Market matrix.

Sub-market	Traditional telephony (4.6)	Enhanced telecommunications (4.7)		Private data networking (4.8)		Internet access & services (4.9)	
Enabling Technologies within markets (columns)							
	Analog Wireline	Digital Wireline	Digital Wireless	Digital Wireline	Digital Wireless	Digital Wireline	Digital Wireless
Services (rows)							
Local phone (PSTN)	YES	YES	YES	NO	NO	YES	YES
Long-distance phone (PSTN)	YES	YES	YES	NO	NO	YES	YES
Non-PSTN voice	NO	LTD	YES (1)	YES	YES	YES	YES
Conference calls	Limited	YES	YES	YES	YES	PSTN & IP	PSTN & IP
Voicemail	NO	YES	YES	YES	YES	YES	YES
Internet access	via modem	YES	YES	YES	YES	YES	YES
Private data networking	NO	YES	YES	YES	YES	YES-VPN	YES-VPN
Fax machine	YES	YES	YES	NA	NA	NA	NA
Fax server	NO	YES	NO	YES	YES	YES	YES
Video conferences	NO	YES	NO	YES	YES	YES	YES
Interactive video auctions		YES	NO	Intranet, Extranet	Intranet, Extranet	YES	YES
Web design		NO	NO	Intranet	Intranet	YES	YES
E-Commerce		NO	YES	Extranet	Extranet	YES	YES
AIN/CTI	NO	YES	YES			CTI	CTI
Basic 911	YES (3)	YES (3)	YES (2,3)				
Enhanced 911	NO	YES (3)	(2,3)				
Text paging	NO	YES	YES	LTD	LTD	YES	YES

NOTES: (1) iDEN technology only, (2) not yet location specific, (3) depends on service area.

The extension of hypercommunication services to rural Florida and agribusiness depends heavily on the production economics of the technologies (for carrier and customer alike) used to deploy technologies and deliver the market for services to rural and urban agribusinesses alike.

As new services become available, agribusinesses must consider their own needs to see how new choices fit into present or future business strategies.

4.6 The Traditional Telephony Market

This section covers the sub-market for traditional telephony services and technologies. There are two parts of the traditional telephony market. First, traditional telephony includes analog POTS (Plain Old Telephone Service) over a local copper loop or trunk[29]. Second, traditional includes long-distance calling, directory, operator, and other services generally available once the December 31, 1983 MFJ (Modified Final Judgement) broke the AT&T Bell System into LATAs and RBOCs. Traditional services are part of a Bell System inspired regulatory mindset (at both the federal and state level) that gave the U.S. monopolized telephone service.

Traditional services originated from what was (before 1984) arguably a textbook example of natural monopoly[30] because of the technologies available then. The high fixed costs of infrastructure investment, engineering, design features of the network, and other factors combined to give AT&T a legally defined natural monopoly, which was regulated by state and federal authorities. From 1984 to 1996 the RBOCs (Regional Bell Operating Companies) such as BellSouth (which resulted from the breakup of AT&T), along with independent carriers such as GTE and Sprint served as local monopolies in non-overlapping service areas within Florida. Several smaller rural telephone companies (such as Indiantown Telephone, Quincy Telephone, and St. Joseph's Telephone) served rural parts of the state.

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[29] Traditional analog cellular service, the only wireless example, essentially follows the wireline case. Details about other kinds of wireless telephony (such as digital cellular and PCS) are covered in 4.7.5.

[30] See Chapter 5 for a discussion of natural monopoly and other rationales for regulating various hypercommunication sub-markets

Today in Florida, traditional telephone services are provided by LECs (Local Exchange Carriers) and by IXCs (Interexchange Carriers). However, deregulation has changed both the local and long-distance markets from the AT&T days. In the local market, the first kind of LEC, the ILEC (Incumbent Local Exchange Carrier) is the monopoly telco that serves a particular area or exchange. The ILEC is also the owner and builder of the telephone plant (especially the last mile segment). All other LECs are ALECs[31] (Alternative Local Exchange Carriers) established through state and federal de-regulation specifically to compete with ILECs. ALECs can resell ILEC services and offer their own services in addition to exchanges (or parts of exchanges) wherever they choose. ALECs normally use the ILEC's facilities in the access level, though facilities-based ALECs have their own switches, POPs, and transport level equipment. Even after the 1996 TCA, ILECs are legally "carriers of last resort" who must furnish basic telephone service to all reasonable locations within their service territories even if ALECs are unwilling or unable to provide service.

IXCs are long-distance carriers who also use part of the ILEC's local loop to carry long-distance calls to a POP for transport. While only one ILEC can serve a particular location, 363 ALECs and 988 IXCs offer service in Florida (especially in urban areas) now that traditional services have been de-regulated [FPSC, 2000]. In spite of these numbers, only 4.3 percent of Florida businesses used an ALEC rather than an ILEC for local service as of March 1999 ["You Have to Make the Call on Phone Service", Greg Groeller, *Orlando Sentinel*, March, 15, 1999].

This section has two sub-sections. The first sub-section (4.6.1) covers traditional services: local calling, other local services, and long-distance services. Then, traditional telephony access technologies and CPE (4.6.2) such as telephone sets, key telephone systems, and PBXs are mentioned. Typically, the access technology used (lines, trunks, PBXs) depend on the POTS equipment selected by a business.

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[31] ALECs are known nationally as CLECs (Competitive Local Exchange Carriers).

4.6.1 Traditional Telephone Services (POTS)

In 1998, Florida ILECs, ALECs, and IXCs realized $15 billion in telephone revenues, up almost 30% from the 1995 level [FCC, "Telephone Trends", 2000, p.19-7]. It might appear as though revenues from these traditional telephony services (provided by ILECs and IXCs) would consist mainly of charges for local and long-distance telephone calls. In reality, however, the picture is more complicated because local service revenues consist of a mix of PSTN access charges, toll calls, and many miscellaneous revenues. Forty percent of what IXCs collect in long-distance charges goes back to the LEC as access charges.

In fact, as Table 4-16 shows, there is a broad array of traditional business telephony services beyond telephone calls. As the columns show, ILECs may make more money on directory advertising, for example, than they do by providing special local calling services. Indeed, depending on the agribusiness, a larger share of its telephone budget may go towards local calls or directory advertising than is spent on long-distance calling.

The first item in Table 4-16, lineside local telephone service, includes an inbound-outbound voice grade (analog) line or multiple lines, along with local calls.[32] Depending on the local exchange, an agribusiness may be able to choose from using the ILEC or from dozens of ALECs for local telephone service. Typically, unlimited calls to the local exchange together with calls to a group of surrounding exchanges serving nearby areas (the local calling area) are included in a monthly per line rate. However, some new carriers charge for local calls, especially if the line is meant for inbound service only.[33]

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[32] Trunk lines (special groupings of multiple lines used for local or long-distance services) and multiple trunks are discussed at the end of this section as trunkside services and also in 4.7.

Table 4-16: Traditional telephony services.

Item	Pricing	Share of bus. phone expense	Share of ILEC revenue	Share of IXC revenue
Lineside local line(s) (voice grade line, local exchange calling, local calling)	SLC, Fixed monthly charge, per line	28%	56%	SLC & US, <5%
Enhanced local, extended local calling, intra-LATA calling	Traffic-sensitive (variable) charges.	> 8%	6%	
Operator services (collect, station-station, person-person)	Free or unit-priced.	< 3%	<1%	4%
Repair, installation, line maintenance	Case-by-case.	< 1%	2-3%	Minor
Signaling, touch-tone, tone vs. pulse	No charge or minimal.	Minor-none	Minor	0
Classified directory advertising (Yellow Pages)	Based on ad sizes and categories.	2-3%	over 3%	Minor
Inbound and outbound directory assistance, white pages listings	Unit charges.	<1 %	<1%	Minor
Long-distance telephone service (inter-LATA, intrastate, interstate, and international), IXC trunks	Traffic sensitive: minimum, time-based, step, contractual, & setup.	>38 %	16% IXC access charges	73%
WATS (Inbound and Outbound), FX, 900 number, special prefix	Both per minute & monthly charges.	> 5%	1%	7%
Local & long-distance trunks, multiple trunks.	Per trunk or by bandwidth.	> 12%	over 5%	10.5%

Estimates of revenue shares from FCC, Statistics of Common Carriers, 1999, p.41, pp.166-171; FCC, Telecommunications Industry Revenue: 1998, Table 5 and Table 6, 1999.

To understand the differences among the local exchange, local calls, enhanced calling zones, and extended local calling zones better, an example should help. Figure 4-36 shows a group of exchanges in Hardee, Desoto, Highlands, and southern Polk counties. Within each local exchange, most local providers offer unlimited calling for a monthly fee. The local exchange may include several RAVs (wire centers), and one or more class five COs (see Table 4-8), each with one or more telephone prefixes (NXXs).

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[33] AT&T is currently prevented by law from offering local service. To circumvent this restriction, the company offers pay-by-the-call local calling.

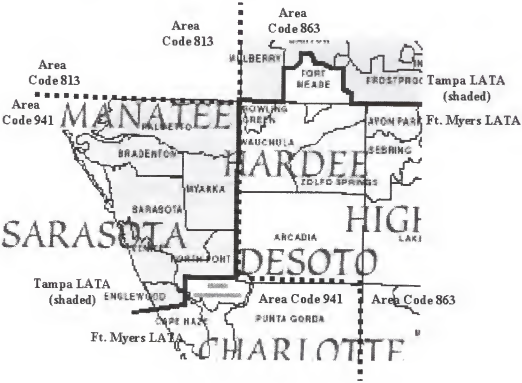

Figure 4-36: Zolfo Springs and surrounding exchanges.

The Arcadia exchange (which covers all of Desoto County) has four NXXs (444, 491, 494, and 993) on one CO. Zolfo Springs has a single NXX (735) in a single CO as does Bowling Green (375). Each exchange has a different kind of FPSC-mandated local calling plan ILECs must offer. Local calling plans are determined by analyzing calling patterns to obtain a PAHS (Probable Area of Highest Service) pattern for calls made from a particular exchange. Local, enhanced local, and extended local calling areas are configured based on the PAHS.

In Arcadia, local calls may be made only within the Arcadia exchange. Calls to Port Charlotte, Wauchula, and Zolfo Springs from Arcadia (extended local calling) are $0.25 per minute for residences, and $0.06 per minute for businesses. The Zolfo Springs exchange can call

Bowling Green and Wauchula as a free local call, and can call Arcadia at extended calling rates similar to those for Arcadia to Zolfo Springs ($0.25 and $0.06). Bowling Green customers may call Wauchula and Zolfo Springs as free local calls, but both business and residential calls to Fort Meade (enhanced local calling) are charged a fixed $0.25 fee regardless of length. Calls from these local exchanges to exchanges outside local, enhanced, or extended areas are classified as long distance. ALECs are free to offer larger extended and enhanced calling zones to their customers, providing that LATA boundaries are not crossed. In some cases, if an agribusiness switches to an ALEC that offers a larger calling area significant savings will be achieved.

Local operator services are provided by the local service carrier (ILEC or ALEC) or by any of the 98 operator service providers in Florida [FPSC, 2000]. Long-distance operator service is provided by the presubscribed long-distance carrier (IXC) or by an operator service provider chosen by the IXC. While no charge is assessed for dialing the local operator to report an emergency, a charge may be assessed for other services per call such as emergency line interrupts and line testing. Long-distance operator services such as long-distance call assistance to obtain credit for wrong numbers or to report call quality problems are usually free. Both local and long-distance operators can provide collect, station-to-station, and person-to-person calls. However, local operators (used in this sense) means intra-LATA long-distance only. Charges for operator-assisted calls are up to several times the setup and per-minute rate of direct dial calls.

Repair, installation, and line maintenance are offered by local telephone companies to subscribers who are adding a line, reporting telephone problems, or who want the LEC to be responsible for inside (customer premises) telephone wiring. Installation fees are changed for every line or trunk connected to the PSTN whether or not the LEC actually installs the wiring at the customer's premises. On-premise wiring and repairs are customarily billed at hourly rates, unless the subscriber pays a monthly inside wiring maintenance charge. In no event are customers supposed to be charged for repairs on the PSTN side of the demarcation line.

Telephone signaling (distinct from the signal that carries the call itself) refers to ringing, dial tone, busy signals, and the dialing technology. An example of extra signaling charges on traditional service includes DTMF (touch-tone) dialing, while custom ringing or stutter dial tone with voicemail are examples of signaling charges for enhanced telecommunications service (explained in 4.7). CPE must be compatible with the serving LEC's signaling technologies, a problem that can lead to telephones that do not ring or offer dial tone (especially possible with trunkside or enhanced services).

Directory advertising is an especially lucrative source of revenue for ILECs, though court cases allow other firms to publish telephone directories also. The annual cost of listings in various classified categories is usually billed on a monthly basis in the LEC telephone bill. Yellow Page directories (whether ILEC or competing) include a new genre of online electronic listings and search operations where advertisers and/or telephone customers of a particular carrier may receive preferential treatment.

Directory assistance can be inbound or outbound. Outbound directory assistance is offered on a per call basis to callers within the business by the serving LEC, while inbound directory is offered to callers by their own LEC or competing providers. Special white page listings are offered by the ILEC (which is required to publish a telephone directory) and in competing directories. ILECs are required to list customers of ALECs in the local directory (and provide their listing databases to independent directory publishers), though this is sometimes not done in a timely manner. Furthermore, the ILEC or ALEC is responsible for ensuring that white page listings are available nationally and internationally for inbound callers so that prospective customers can find a business.

Inbound and outbound directory assistance services include white pages, 411 (1411), 555-1212, and Internet directory listings. Improved inbound directory assistance services may be a way that rural Florida can see dramatic gains in trade for call center industries, retailers, and certain wholesalers. Currently, inbound directory services covering rural areas exhibit a gap when compared to urban areas. In particular, rural areas may be poorly classified by an ILEC because billing and service addresses are not the same in rural carrier or P.O. box required areas. The location given in the directory is the exchange location, rather than the post office location, which can make searching for a business harder. Changes in directory listings in rural areas may take longer to be updated in inbound and online directory assistance databases than those in urban areas.

Agribusinesses that expect customers to find them in white or classified listings should check them to see that listings are available and correct. One study found that from fifteen to forty percent of directory assistance operator calls found either incorrect numbers or no number at all when one was listed [*Seattle Times*, May, 15, 1999]. To save money, instead of purchasing directory databases from the ILEC, ALECs and independent directory providers can purchase listing databases from less reliable sources.

There are five categories of long-distance toll service: extended calling zone calls, intra-LATA long distance[34], inter-LATA intrastate long-distance, interstate long-distance, and international long-distance. The 1996 TCA prohibits RBOCs (but not other ILECs) from offering inter-LATA, interstate, and international long distance under Section 271 of the 1996 TCA. However, RBOCs may offer extended and enhanced toll calling and intra-LATA long-distance as well as local exchange service.

A business must pre-subscribe to a particular IXC or ALEC, but may use a special code to access another carrier on a call-by-call basis if it has lineside long-distance services. Long-distance trunks (trunkside long-distance services) are groups of lines directly connected to a particular IXC's local POP. Calls over LD trunks can be made only through the trunked carrier.

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[34] While LATAs can cross state boundaries, interstate LATA calls in Florida are all local. Interstate LATAs are confined to a few exchanges in the extreme northwest panhandle (within the Mobile, Alabama LATA) and an exchange in extreme northeast Florida (within the Savannah, Georgia LATA). See Figure 4-37.

Long-distance dedicated circuits are also available for fixed or measured rather than metered (per minute) rates.

To understand long-distance calling (and to understand how many enhanced telecommunication and data networking services are priced), it is important to understand LATAs or (Local Access Transport Areas). LATAs were created in the MFJ (Modified Final Judgement) that broke up the Bell System to differentiate IXC service areas from those where ILECs and LECs could provide long-distance services.

Figure 4-37 shows the LATAs in BellSouth's service area in the southeast United States.

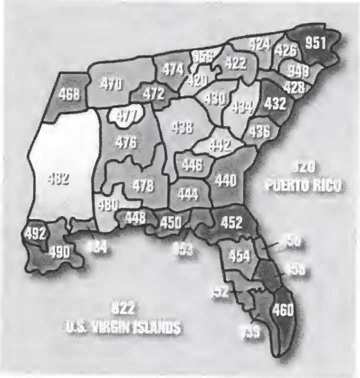

Figure 4-37: LATAs in the Southeast U.S.A.

Calls placed from locations inside a LATA to other locations within the same LATA (but outside of all local calling areas) are *intra*-LATA long-distance calls, handled only by LECs and ILECs. Most LECs charge for non-local calls inside the subscriber's LATAs by the minute, though some ALECs allow free or per-call charges for *intra*-LATA long-distance. Calls from one

LATA to another (*inter*-LATA long-distance), can only be handled by IXCs. Inter-LATA calls may be intrastate (within Florida) or interstate (from Florida to another state). Depending on the rate structure and carriers chosen, intrastate calls may be more expensive than interstate calls. In some cases, intra-LATA calls may be the most expensive of all.

When switching carriers, it is necessary to compare a sample of bills over all types of calls to see if savings will be achieved. Agribusinesses are often tempted by low rate quotes on interstate long-distance to switch to a new carrier. Quite often, their long-distance bill actually rises because of higher intrastate or international rates offered by the new carrier. Furthermore, agribusinesses that direct dial international calls must also consider rates to their most frequently called countries.

A business must choose a different pre-subscribed carrier for *inter*-LATA long-distance (IXC) than it does for local calling (LEC), and may use still a third pre-subscribed carrier for *intra*-LATA long-distance. It is a good idea to shop carefully. Because of the complexity of calling plans (and due to the fact that rates are constantly changing), businesses can use special adaptive rate dialing equipment to take advantage of the lowest prices to a particular place at a particular time. An important reason that the telephone transport and Internet are converging into a single hypercommunications network is that savings of from fifty to eighty percent on long-distance calling can be easily realized. This point is discussed further in 4.7.4 (voice-data consolidation technologies) and in 4.9.7 (Internet convergent applications).

Figure 4-38 [FPSC, Division of Communications, 2000] shows a map of Florida's 67 counties, 11 LATAs, and 13 area codes (NPAs). Many area codes contain more than one LATA (such as in the panhandle) but in other cases (such as the Southeast LATA), one LATA contains more than one area code.

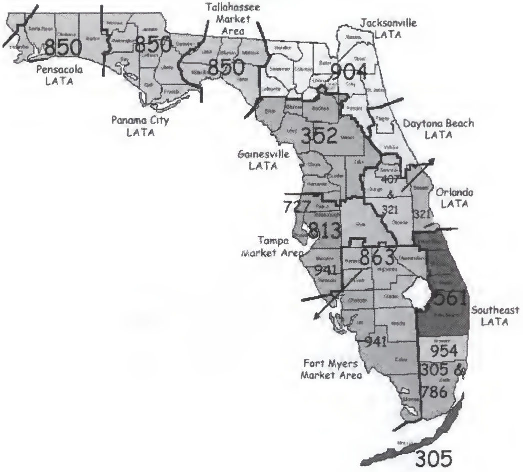

Figure 4-38: LATAs (lines) and area codes (shaded) in Florida.

In Florida, area codes cross LATA boundaries in only two cases. First, the 941 NPA is partly in the Tampa market area (LATA) and partly inside the Fort Myers market area (LATA). Second, most of Polk County is in the Tampa LATA, but it is joined in the new 863 NPA by other counties that are inside the Fort Myers LATA. Hence, inter-LATA long-distance and intra-LATA long-distance calls may be in the same or different area codes.

Long-distance tolls are calculated in several ways, depending on whether an agribusiness has a contract to use a minimum number of minutes per month or the IXC charges all calls on an individual basis (open rate). Generally, the calculation depends on three general rate categories: metered (per minute), measured (rate based on lumpy usage categories), or fixed (unlimited calling, charged monthly). Each category can apply to traffic sensitive (TS) and non-traffic sensitive (NTS) service.

The open rate or contract cost of a single long-distance call may include a setup charge, minimum toll, time-increment tolls, and step charges. A setup charge (typically for the first minute) may apply for every completed call, regardless of the call's duration. Setup charges are fixed, TS fees, added to time-based (measured), step (metered), and minimum tolls.

Time-increment tolls apply for each time interval that a call is in progress. They are for metered services and may be per minute or fraction thereof, per second, or based on other time intervals. Step charges apply to all calls until a minimum per-call length (metering threshold) has been reached. After that point, calls are charged in steps governed by blocks of time. For example, if the step increment time is twenty minutes, calls twenty minutes or less are charged at a single block rate. However, calls longer than the step increment time are charged at a different (usually higher) time-increment toll for the full period the call lasts beyond the step time, so the call becomes a mix of measured and metered rates.

Contracts between an IXC and a business may specify minimum toll rates good on all LD time or fixed minute plans. Lower rates are extended for quantity discounts and for customers who sign agreements not to change carriers for from six months to five years or more. Minimum tolls represent the minimum per minute cost of all calls. Typically, contractually based minimum tolls are contingent on whether the customer places enough calls to qualify for a quantity discount over a certain amount of time. The lowest possible time-based toll is applied to all calls in months when a business uses at least the contractual number of minutes. Higher open rates apply for months when the stated quantity of minutes or hours is not used. Under fixed-minute long-distance plans (especially common in the mobile telephony market), customers agree to pay for a particular amount of long-distance (or local) calling whether they use it or not. In some cases, unused minutes may be "banked" or rolled over for use in future months.

While long-distance is covered here under traditional services, it is important to realize that enhanced telecommunications technologies, CTI integration, and the Internet allow adaptive rate systems as well as the traditional open rate (per minute) and contractual long-distance markets. A business can program specialized telemanagement equipment to take advantage of highly fluid demand conditions to use the lowest cost IXC based on the time of day, day of week, destination, and expected length of a call automatically. Larger businesses can even take advantage of forward markets for long-distance bandwidth between points such as the San Francisco-based Rate Exchange.

Free long-distance calls may be placed by callers over computers (without needing a telephone) via their Internet connection to any PSTN telephone throughout the U.S., Canada, or even internationally using free services such as www.dialpad.com. Free Internet calling is underwritten by sales of advertising banners that the call originator sees while in conversation. Call quality is beneath that of pay long-distance, with numerous QOS issues such as connection establishment delay, latency, jitter, and poor voice quality to contend with as well.

Eventually, it is possible that much long-distance calling will become included in fixed rate plans regardless of destination and call length. However, at present, QOS problems limit so-called free calling (actually paid for through a fixed access charge or by the time cost of viewing advertisements). Importantly, there are regulatory barriers as well (mentioned in Chapter 5) that may prevent free long-distance from becoming widely offered.

WATS (Wide Area Telephone Service) lines include both inbound and outbound long-distance. Inbound WATS includes toll free calls to interstate and intra-LATA 1-800, 1-877, and 1-888 numbers from a calling area that can be a single LATA, an entire state, or nationwide. Outbound WATS is a contractual service offered by an IXC to specific area codes or nationwide and even internationally to specific countries. Tolls may be based on the location called (metered distance rates), per call (metered per minute), on a step rate (measured), or on a fixed charge basis, no matter the length of the call or the location called. Businesses can also earn money from

900 number calls where the calling party pays for the call and an extra charge to obtain information or other services.

FX (Foreign Exchange) and special prefix services are similar to WATS because callers do not pay for FX calls. FX is unlike WATS because the call is made to a local number associated with a local exchange, local NPA, and local NXX. The calling party calls a local number and is automatically connected to the business paying for FX service in the next county or next state. Inbound-only FX routes incoming calls through such "virtual" local FX numbers onto to DID trunks (specific lines inside the business that pays for inbound FX). Many different telephone numbers may be mapped to a single DID line.

FX service is often accompanied by specially targeted white and Yellow Page listings so that the FX business appears to be local to the caller. For example, the local exchange name may be used to show a local address rather than use the distant city name and address where the call is received. Charges are made for the FX telephone number, the DID trunk, white and Yellow Page listings in the FX exchange telephone books, and calls typically are subject to long distance tolls as well.

Outbound FX service allows businesses to call numbers in the virtual exchange as if they were local calls. This can result in savings on long-distance calls that would otherwise be charged a higher rate. Other special prefix services use prefixes such as 203 that do not require callers to dial one plus the area code within extended calling areas or LATAs, or even across area codes. In much of Florida, 203 numbers may be called as a local call in every area code. The business would pay for 203 numbers in each area code along with the appropriate open or contract long-distance rate.

The last item in the list of traditional telephony services includes trunkside services (single and multiple trunks). While multiple telephone lines may be charged at a lower per line rate than single lines, many businesses choose to have special groups of lines called trunks attached to a business telephone system that functions as an on-premise telephone network.

Trunks and multiple trunks are groups of lines with special rates that connect to specialized CPE such as PBXs thus allowing businesses to be flexible in the number of incoming, outgoing, and long-distance lines. To cover trunkside services adequately, the next sub-section covers telephone systems, PBXs, and other traditional telephony CPE.

4.6.2 Traditional Telephony Access Technologies and CPE

Traditional telephony access for businesses can include multiple line or trunks (groups of multiple lines). The form of access a business chooses (typically a mix of trunks and multiple analog lines is selected) varies based on the telephone system of the business. The form of access also depends on calling patterns, and whether there is a need for specialized lines, extra telephone numbers, or custom call routing.

A business telephone system may be a traditional key system or a Centrex/PBX. Traditional key telephones (now almost extinct) are simple multiple line telephone systems used primarily in small offices that cannot switch calls elsewhere within the business. Key systems are lower-end individual telephone sets that cannot transfer calls within the business or to other locations. Key systems can handle from two to about 100 telephone ports. There is a large difference in capability between traditional key systems and enhanced (or hybrid) key systems to be discussed in 4.7.

Traditional key systems can recognize up to 20 telephone lines on a telephone set that can be individually programmed to recognize calls from certain lines only. Most traditional key sets have hold and volume controls, but typically do not have any kind of computer brain that the next kind of system, a PBX does. Hence, traditional key systems cannot offer voice mail (except on the telephone set itself) or other services. They are able in some cases to offer caller ID, hold, intercom, and speed dialing, but some of these require payment for each service on a per line basis to the LEC. Since traditional key systems are not switches, as PBXs are, businesses that use them use multiple business telephone lines rather than trunks. A single key set can answer multiple lines and transfer calls by using intercom announcements to alert staff members to pick up a particular line, often using lighted signals on the telephone set. Individual telephones may each be programmed to allow long-distance outbound calling and other features, though some key systems have KSUs (Key System Units) to control available features.

PBX stands for Private Branch Exchange. Historically, PBXs consisted of a local loop telephone trunk (group of telephone lines) ending at the PBX, a switchboard, and the copper lines leading from the PBX to individual telephone sets at a business location. In the late 1960's, electronic switchboards replaced electromagnetic switchboards where calls were manually switched by a human operator. By the 1980's, computers began to be used as the "brains" behind electronic switchboards. Traditional PBXs take advantage of line consolidation so that there can be more lines than telephones, saving businesses money. Furthermore, since many calls are within the business, the PBX is a switch for those calls.

Traditional PBXs use proprietary protocols so that additions to the system require that additional equipment be purchased from a particular manufacturer. Furthermore, many traditional PBXs are no longer supported by the manufacturer so businesses must buy new systems since there is no authorized way to replace equipment. Traditional PBXs, even though they used a computer for switching could handle data only at limited rates up to 19.2 kbps, necessitating the use of separate lines for modems and faxes [Tower, 1999]. With a PBX, a single line telephone set can gain access to a pool of outgoing lines (a shared trunk) through users dialing an access code such as 8 or 9 before obtaining dial tone.

Even traditional PBXs support numerous system services such as DID (Direct Inward Dialing), hunt groups, pick-up groups, call detail services, and least call routing for toll calls. DID allows each individual in the business to have his own telephone number without requiring an equal number of telephone lines. The PBX switches the DID number to the appropriate station. Hunt groups allow the PBX to automatically route incoming calls to the first free telephone line in a particular group without a human operator to connect the call. Pick-up groups permit members of a group to answer calls (or have calls forwarded) when a particular telephone is unattended, again without action by a human operator. Call detail services allow logs (even on a per station basis) to be automatically recorded to keep track of long-distance charges, call lengths, and other call management details. More advanced PBXs work with digital and analog trunks that can be dedicated local ISDN-PRIs connected to an ALEC's POP or dedicated long-distance ISDN-PRIs connected to an IXC's POP. These uses are covered in section 4.7.

PBX stations (individual phones) can be programmed from the central computer to allow call waiting, call forwarding, call transfers, speed dialing, voice mail, do not disturb, and automatic callback of busy or no answer numbers. Changes in extension numbers, ringing, hunt groups, and other features are done through the PBX computer rather than by programming individual telephones or rewiring connections. Outbound long-distance and other toll calls can be blocked through the PBX computer for any telephone set or group of telephones in one step. A central PBX or a distributed network of PBXs can be used to link separate buildings or floors. Later versions of PBXs are covered in 4.7 with enhanced services.

Centrex (also known as ESSX$^{(R)}$ by BellSouth) is a virtual PBX controlled from the telephone company CO. With Centrex service, most traditional PBX services are available for a monthly service charge from the LEC. Centrex service involves leasing a PBX (and often telephone sets) from the ILEC, rather than a PBX that the business owns. Changes to the system must be ordered through the telco (ILEC or ALEC) with separate charges for hold, music on hold, do not disturb, distinctive ringing, and other options that are standard on a CPE PBX.

Some argue that Centrex is gradually becoming a technological legacy of the pre-deregulation era, as even small businesses find that new generation PBXs support special features along with enhanced telecommunications services more affordably. However, Centrex offers higher reliability (designed to be down less than three hours over 40 years) than an in-office PBX, is impossible to outgrow, and does not require the investment cost of a PBX.

4.7 The Enhanced Telecommunications Market

As convergence occurs, the overlap among the sub-markets named in sections 4.6 through 4.9 will become ever more substantial. Nowhere is this more the case than when considering how the enhanced telecommunications market overlaps traditional telephony. The two overlap in two ways. First, many enhanced telecommunications services are simply advancements in business telephone equipment such as new kinds of PBXs. These advancements in CPE are summarized in 4.7.1.

The second area of overlap comes because most enhanced telecommunications services are supported by the ILEC copper (or sometimes fiber) infrastructure. Hence, all enhanced telecommunications services have to do with voice communications, though many of the individual offerings also have private data networking and/or Internet applications. Though cablecos and electric utilities have fiber or coax infrastructures that can support enhanced services as well, they are new entrants in a sub-market dominated by telcos. While terrestrial wireless carriers have established presences in paging and mobile wireless telephony, terrestrial fixed carriers (such as WLL and LMDS) and satellite technologies can also (or soon will) support enhanced telecommunications services outside of the mobile market.

In some areas of Florida, ILECs are the only vendor agribusinesses can buy enhanced services from, while in other areas ALECs resell them. In still other areas, even the ILEC is not able (for engineering or marketing reasons) to offer enhanced services. In some cases, ALECs are able to resell unbundled ILEC services when the ILEC cannot profitably introduce service [Ackerman, 1999]. However, some rural areas of Florida may wait years to get particular enhanced services considered vital by urban business.

The enhanced telecommunication sub-market also overlaps both the private data networking and Internet markets. Some of the access services (both dedicated and circuit-switched) mentioned in this section are targeted towards the enhanced telecommunications market, though they can be used as well for data networking or to obtain Internet access. Similarly, certain WAN data networking and Internet offerings can be used for voice though their attention is focused upon the data and WWW side.

There is a subtle evolutionary chain leading from POTS up to enhanced services and then on to both data networking and the Internet that can only be seen through a sequential presentation. The evolutionary stages depend on the needs and sophistication of the agribusiness users. Agribusinesses must adopt POTS before they become customers for enhanced telecommunications. Additionally, private data networking adoption follows enhanced telecommunications as communications sophistication develops with each step beyond POTS the agribusiness takes. Due to the connection between traditional modems and the Internet, its evolution is harder to see because it is associated with POTS and data networking, though enhanced services may be used as combination voice and Internet access loops.

This evolutionary chain is economic as well as technical because as costs fall, choices rise, while reliability varies as communications use progresses from POTS upward. After the sequence of sub-markets has been laid out, the path to convergence is more easily seen by glancing backwards down the evolutionary chain. Furthermore while the overlap exists, the enhanced telecommunication sub-market focuses on common carrier communications, while the data networking sub-market focuses on private connections. Since it is a public data network, the Internet shares some points of similarity with both enhanced telecommunications and data networking. Additionally, the Internet is able to combine features of interpersonal and mass communications to offer lower prices, greater QOS complexity, and the enormous business potential of hypercommunications convergence.

The continuing existence of these separate sub-markets depends importantly on what is an increasingly artificial distinction between voice and data. Enhanced telecommunications offerings put voice first and data second, while private data networking puts data first and (if the network manager looks at voice) it may be put third, behind Internet. However, recent developments in enhanced telecommunications offer a way for agribusinesses to migrate from separate voice and data networks to hypercommunications converg ence.

It is important to realize again that line consolidation means that a business will have more telephones that telephone lines. It may choose to have more telephone numbers than telephone lines or telephones as well so that employees may have their own private number without requiring their own private line or for other business reasons. The main idea behind advanced telecommunications services is that line consolidation allows businesses with multiple telephone lines to purchase trunks rather than lines, leading to significant savings on monthly telephone bills. Some trunks can also be used to access private data networks such as WANs or the Internet while carrying telephone calls. Separate trunks may be needed for long distance, WATS, DID, FX, data, and Internet depending on business needs.

Table 4-17 concentrates on voice only or combination voice-data offerings as covered in this section. Some of the services in Table 4-17 will reappear in slightly different contexts in the private data networking section (4.8) and the Internet section (4.9).

Table 4-17: Enhanced telecommunications market offerings.

Item	Sec.	Description
Enhanced telecommunications CPE	4.7.1	Telephone and computer equipment (DTE & DCE), software, & protocols needed for enhanced telecommunications services.
CO & AIN technologies, call center services	4.7.2	Enhanced telephony carrier services & technologies necessary to support call centers & CTI
Dedicated circuit services	4.7.3	Joint data and PSTN voice access via T-carrier, x-DSL, cableco & fiber optics.
Circuit-switched digital services	4.7.4	Joint data and voice PSTN access & switching via ISDN-PRI and ISDN-BRI.
Digital cellular & PCS	4.7.5	Mobile telephony & related services.
Paging and wireless messaging services	4.7.6	Handheld one & two-way wireless paging & e-mail.

Since BellSouth and other ILECs offer thousands of specific services, this section can only touch generally on a few of the more important enhanced services available to agribusinesses. Importantly, the cost of equipment and services has become more competitive in the new de-regulated environment so that even smaller businesses can now afford enhanced services.

4.7.1 Enhanced Telecommunications CPE

A variety of CPE is available to support enhanced telecommunications services. Table 4-18 shows some of the most important examples. Enhanced telecommunications CPE ranges from PBXs that replace traditional PBXs to DTE and DCE needed to use dedicated or circuit-switched services to fully convergent IP PBXs that merge data and voice together throughout the business.

Because of the sheer volume of new technology, Table 4-18 is incomplete and some entries that have been described elsewhere get no additional treatment here. Since many enhanced services still have a voice focus, the most important piece of equipment is the PBX. As was mentioned in traditional telephony, a PBX is a collection of cards, computers, wiring, and other hardware and software that control switching of telephone calls within a business. Even traditional key telephone systems have become hybrid key-PBXs, able to perform many of the functions that used to require a PBX.

Two new types of PBXs have been developed to support different focuses of enhanced telecommunications services. Before they are covered, it may help to see how the traditional PBX has developed into a LAN-based PBX such as the one shown in Figure 4-39. From the telephone network, trunk lines (switched T-1 or ISDN for local service) and possibly a dedicated LD T-1 or ISDN-PRI trunk lead into the business to a PBX switch, which in turn is attached to the LAN. A fax server and voicemail server can be directly connected to (or part of) the PBX, just as individual telephone sets are directly connected the PBX only. IVR hardware (Interactive Voice Response), predictive dialing equipment, and an e-mail gateway connect to both the PBX and LAN in order to enable CTI applications.

Table 4-18: Enhanced telecommunications CPE.

Item	Description	Services used with
LAN-based PBXs	PBXs that use telephone server for brains and some interaction with LAN for CTI use.	Circuit-switched, dedicated circuits, call center, other advanced telephony.
Communications Servers, CT-PBXs & IT-PBXs	Convergent PBX with full CTI, unified messaging.	Above plus full CTI applications over packet-switched, Internet, and cell-switched circuits.
Predictive dialers	Allow outbound calling over cheapest carrier automatically, only answered calls are connected to caller.	Telemarketing, call center, telemanagement, CTI.
IVR systems	Inbound callers use touch-tone or voice responses to make routine inquiries, reach departments, and leave messages.	Call centers, telemanagement, CTI.
DSU/CSUs, NIC-NTs, NIUs	CPE Edge devices that terminate a circuit.	DSU/CSU (T-1, T-3, DS-0), NIC-NT (ISDN, SONET), NIU (DSL).
DACS, channel banks, multiplexors, demultiplexors	Used to configure trunks and split dedicated circuits into multiple channels.	Telephony (T-1 and ISDN-PRI), data networking.
Other DCE	Multiplexors, transcoders, channel banks, routers, gateways, repeaters.	Varies.
Digital telephones	Allows integration of telephone calls with other applications, better call processing, harbinger of move to single network.	Certain PBXs. Reduces need for edge devices on digital lines.
Fax servers	Automate & manage inbound & outbound fax traffic.	Faxes via PSTN, corporate network, & Internet.
Fixed wireless CPE	DCE & DTE that allow wireless local loops to be established. Includes antennas.	WLL, DEMS, MMDS & LMDS access to PSTN, data networking & Internet.
Mobile wireless CPE	Individual combination DTE/DCE devices for mobile users.	Cellular, PCS, paging & wireless messaging.

Note that an ISDN-PRI, T-1, or T-3 connection to the PSTN (telephone network) is assumed in Figure 4-39. All voice and data communications flow through the telephone network, while data transfers are accomplished by modem only. Data rates over modem in such a configuration are typically limited to 19.2 kbps because the PBX performs analog and digital conversion slowly.

LAN-based PBXs such as the one in Figure 4-39 use parallel activity architecture [ECTF, 1997, p.15] Also called third-party connection architecture, parallel activity LAN PBXs switch only telephone traffic to terminal devices (DTE). As calls come in to an order or call center in the sales or customer service department, individual computer stations can provide information about callers and open order screens because of equipment that synchronizes telephone calls with computer ordering applications. Calls are answered by an automated attendant (a recording) and an ACD (Automated Call Distributor) routes them to the first available operator. Callers enter the extension or speak the name they want to reach. Often, another part of this system (called more generally IVR for Integrated Voice Response) asks callers for their account number or gives them certain menu options such as the ability to check balances, order status, etc.

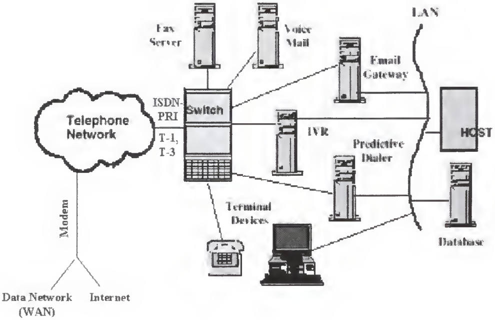

Figure 4-39: LAN PBX legacy system

The IVR ACD system may have options asking what department or extension the caller needs as well. If callers know a specific extension, they may dial that extension directly, or automatically reach voice mail or reach a coworker's telephone in a hunt group if the extension is unanswered. Incoming order or information calls can be transferred automatically to a human operator screened for further information by the IVR before transfer. Often, the caller follows a (possibly long) sequence of menu choices or must enter account numbers or other information through the IVR. However, when callers leave the IVR system (by requesting a transfer to a "real person") the information entered through the IVR is not on the computer screen of the "real person" who gets the call. This is because there is no API (Application Programming Interface) to send a record of the IVR session to the answering operator.

More recent LAN-based PBXs have a telephony server-PBX link, with client computers linked to the PBX (via the LAN) and individual telephones linked to the PBX via traditional lines as Figure 4-40 [ECTF, 1997, p. 15] shows. While the server provides the brains for the telephone system and allows some CTI interaction with individual client computers, individual computers are still not directly linked to individual telephones. The PBX does not carry much (if any) data or Internet traffic, since separates circuits (or sets of circuits) are used for data, Internet, and voice.

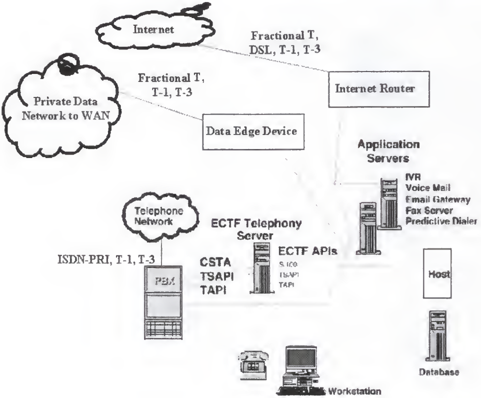

Figure 4-40: ECTF telephony server, PBX attached.

The ECTF-compatible system shown in Figure 4-40 assumes businesses maintain separate voice and data circuits, but allows them to keep their existing PBX (if it is compatible with ECTF standards). IVR (and other operations) are better synchronized with telephone callers' actions. Incoming PSTN calls come through the PBX where they are transferred to a particular telephone extension or are sent to the telephony server. APIs (Application Program Interfaces) are used to interconnect various kinds of telephones, computers, and servers.

Microsoft's TAPI (Telephony Application Programming Interface) and Novell's TSAPI (Telephony Services Application Programming Interface) are two common *de facto* API standards. TAPI provides first-party connections (individual telephones are hardwired to an associated PC) while TSAPI provides third party connections (any telephone may be associated with any PC through parallel activity tracking) [Bezar, 1995]. Third party connections have more flexibility since each user has access to the PBX through the LAN.

Previously, such systems were available only to large businesses with mainframe computers or elaborate telephone networks, but new LAN-based PBXs are within the reach of smaller businesses and can be tailored to specific needs. Instead of being forced to use complicated proprietary hardware and software that operate only with equipment purchased from a single vendor, the ECTF standard lets businesses choose from many software manufacturers and PBX makers when they install and upgrade systems.

Newer LAN-based PBXs may be used with circuit-switched or dedicated circuits (such as the T-1 or ISDN-PRI connections as shown) so that call center and advanced telecommunication services are available to all suitably equipped stations [Bezar, 1995]. These services (detailed further in 4.7.2) include caller ID, voicemail, predictive outbound dialing, screen pop inbound call reception, and other features.

Another advantage of newer LAN-based PBXs (such as the ECTF standard shown in Figure 4-40) is that the IVR and other equipment are directly on the LAN so that caller information is more easily seen by employees. Hence, employee time is saved because information that customers have already provided does not have to be reentered. Customers may also be less annoyed, not having to give information twice. Another advantage of LAN-based PBXs is that changes to the telephone system, billing information, and other telemanagement functions can be available to managers throughout the agribusiness without having to be at a particular location. LAN-based PBXs are an intermediate step between traditional PBXs and fully converged CT or IP PBXs.

One step towards a converged voice-data network is to get rid of the PBX. Figure 4-41 shows a telephony server directly attached to the telephone network without a PBX [ECTF, 1997, p. 14].

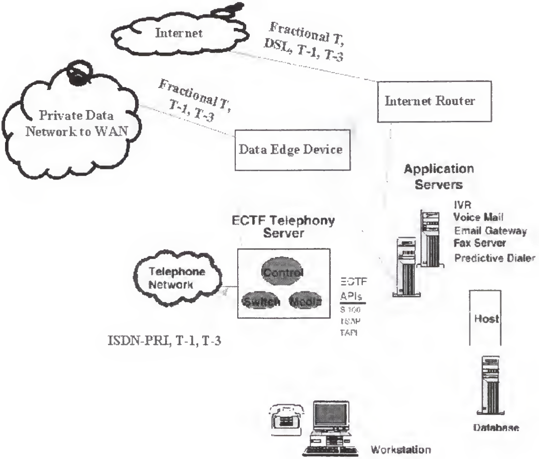

Figure 4-41: ECTF telephony server, attached to network (no PBX).

This system is perfect for businesses wanting PBX CTI functionality without having to buy an expensive PBX that may become obsolete in just a few years. The ECTF telephony server standard allows software upgrades in the server to support new services or changes in circuits. In this way, the business has more flexibility than it would with a closed, proprietary PBX since PBXs are compatible only with certain telephones, software, hardware, and particular kinds of signaling for access connections to the telephone network, etc. This solution is ideal for a start-up business, for a business that has experienced such rapid growth that it has outgrown its PBX, or for a business that has never used a PBX.

Note from Figure 4-41 that the telephony server has three essential elements: control, switch, and media. In such a distributed architecture, the application servers function as clients of the telephony server The telephony server controls calls and applications that process calls, making the call rather than the application the center of interest. The server is able to switch traffic within the business and may serve as a data switch (able to function as a data edge device as well). The telephony server is able to store, buffer, and switch various message types (media) ranging from telephone calls, voice mail, faxes, e-mail, and video conferencing.

Another kind of PBX (which is not actually a PBX at all, but an all-in-one communications server) is the CT or IP PBX (Figure 4-42). These PBXs also called integrated communications servers, handle more than the telephone switchboard traffic of the telephony server. Voice, fax, video, Internet, and data travel through the same conduit in the business (there is no difference between LAN and telephone wire) and over the same access connection. The communications server is an edge device, router, switch, and other DCE in one unit composed of several modules, such as the applications module shown in the figure.

The CT or IP PBX can represent a tremendous savings in wiring and equipment costs, and allows the agribusiness to pay for only one connection rather than pay for voice, WAN, and Internet access separately. The agribusiness need not have a separate IVR, e-mail gateway, video server, predictive dialer, and voice mail and fax server. Instead these functions are performed by applications on the communications server or hosted elsewhere by an Application Service Provider and accessed via the Internet.

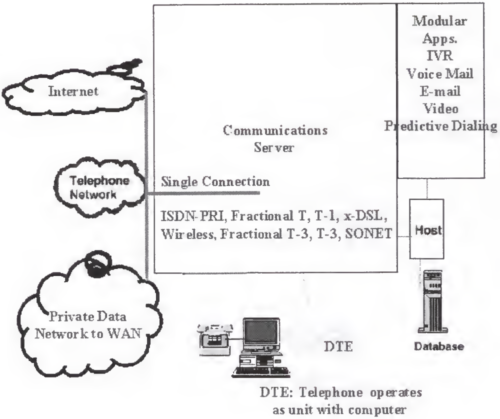

Figure 4-42: Communication server model is a converged network.

The communication server approach uses telephony functions embedded into client computers equipped with voice-data consolidation technologies (4.5.4). Since the telephone operates as a unit with the computer, the complexities of dealing with first-party (standalone) connections and third-party (networked parallel activity) connections are in the past. The DTE client is on a LAN governed by a communications server that controls all incoming, outgoing, and internal voice, data, and Internet traffic. Existing LAN host computers and database servers continue as before, but the LAN host has no communications traffic weighing it down.

CT and IT communication servers are converged voice-data networks with full CTI and unified messaging capabilities. Unified messaging offers the ability to control e-mail, voice mail, and faxes through web browsers, PCS and wireless messaging devices, office telephones, and telephone-computer stations [Riggs, 1999]. Not only can CT and IP PBXs be used with circuit-switched (4.7.4) and dedicated circuits (4.7.3), they may be used over packet-switched (4.8.2) or cell-switched (4.8.3) networks, and even in conjunction with Internet (4.9) connections. The difference between CT and IP PBXs is mainly that IP PBXs can place and receive calls through the Internet, Intranets, extranets, and the PSTN. Users may click on an icon to place telephone calls, get voice mail, and screen both PSTN and IP telephone calls.

Of particular importance, home-based cybercommuters or traveling employees may receive calls made to their office number forwarded anywhere in the world via Internet or Intranet connections, completely avoiding long-distance charges. IP communication server market growth will be driven by long-distance savings of up to 90%. However, even with superior telemanagement, and lower administrative costs, the promise of communication servers depends on whether manufacturers can launch reliable and user-friendly applications [Frost and Sullivan, 2000].

The new convergent PBXs reduce accounting and time costs of businesses in many ways. Employees need not check for voice mail, e-mail, fax traffic, and internal office memos in four separate systems, everything is in one mailbox. Secondly, access to these four kinds of message traffic does not require that any particular device be used or even an employee's presence in the office. Third, the fixed costs of purchasing separate DTE (computers *and* telephones), separate DCE (data switches, PBXs, Internet routers), expensive stand-alone servers (such as IVR, e-mail gateways, voice mail servers, etc) fall, replaced only by an investment in a communications server. Finally, instead of paying for separate voice, data, and Internet connections each month, agribusinesses have one monthly communications pipeline charge.

To complete the discussion, a return to Table 4-18 shows that the rest of the list would be unnecessary if all businesses have communications servers. However, the communication and telephony server models are hardly available or appropriate for most agribusinesses at this stage of convergence. The rest of the entries in the table include CPE that is still being purchased and probably will be for some time.

DSU/CSUs (Data Service Unit and Channel Service Unit), NICs and NTs are edge devices (DCE) used to terminate dedicated or switched circuits at the demarcation point on the customer premises. Typically, CPE are purchased by the agribusiness or leased from the carrier. Often, CSU/DSU functions are integrated into routers so that convergence is simplified. Other DCE include such items as multiplexors, demultiplexors, transcoders, channel banks, routers, gateways, and repeaters. Many devices may only be used with a particular service, carrier, or technology.

Multiplexors allow agribusinesses to change service channeling, often allowing a more efficient use of bandwidth. For example, a T-1 carries 24 64 kbps voice channels. To carry them over a T-1 carrier, a D4 channel bank is needed to split the DS-1 signal into 24 separate channels. In conjunction with other technologies, multiplexors can lead to greater efficiencies. For instance, an agribusiness could double that number to 48 voice channels using a different voice compression technology than standard PCM in telephone sets and multiplex these 48 channels onto the T-1. A demultiplexor would be needed to reverse the process. Other devices such as DACS allow customers to automatically reconfigure how ISDN-PRI or T-1 trunk channels are allocated so as to allow variations in traffic to accommodate video conferencing, Internet access, or other traffic needing more than one channel.

Digital telephones and other DTE are the devices that interact with users. Digital telephones allow integration of telephone calls with other applications and better call processing, making it easier to migrate towards a unified voice and data network. Digital telephones are DTE and DCE together. Digital phones perform ADC inside the telephone set, directly converting the message from an analog microphone (when the local party speaks) into a digital signal that is sent over an end-to-end digital path. Other "digital" telephones are analog devices that rely on intermediate DCE to perform conversions needed for them to operate over digital PBXs or digital connections. The ultimate digital telephone is a PC or thin client with voice capability.

Fax servers automate and manage inbound and outbound fax traffic. Faxes may be sent or received through the PSTN, corporate data network (WAN or Intranet), and the Internet. Fax servers store incoming and outgoing faxes when the network is congested until conditions allow the faxes to be sent. Faxes are converted into e-mails or e-mails converted into faxes and sent to any PSTN telephone with some fax servers.

Other fixed wireless CPE includes DCE and DTE needed to establish wireless access paths. In addition to DCE and DTE, antennas are needed for wireless communications. Most PBXs are not yet compatible with fixed wireless access to the PSTN. However, carriers offering fixed wireless technologies such as WLL, DEMS, MMDS, LMDS, and broadband LEO are expected to provide access to the PSTN with the necessary CPE, as well as data networking and Internet access over the same wireless path. The wireless industry is developing the necessary CPE to offer support of enhanced services. More information may be found in 4.8.5 (Wireless WANs) and 4.4. Mobile wireless CPE includes combination DTE/DCE devices for mobile users. Services supported include cellular, PCS, and paging or wireless messaging. More information on mobile wireless CPE is given in 4.7.6.

4.7.2 AIN CO Technologies, Call Center Services

This section briefly covers the enhanced telephony carrier services and technologies necessary to support call centers, CTI, and the various levels of business PBX and applications. AIN (Advanced Intelligent Network) CO technologies make possible a variety of enhanced services ranging from caller ID and call waiting to ISDN, DSL, and dedicated digital circuits. It may help to begin by defining call centers and relating them to agribusiness.

Call centers are big business in America. Estimates are that over 60,000 call centers existed in 1998, employing some 3.5 million people, and are responsible for as much as forty percent of all telephone calls. Over seventy percent of customer-business interactions and $840 billion in sales went through US call centers in 1998 [Bernett and Gharakhanian, 1999, p. 107]. In the business-to-business (B2B) arena, call centers accounted for $244 billion or 45 percent of B2B sales in 1996 [Sevcik and Forbath, 1999, p. 2]. Telemarketing, inbound catalog ordering, voice interactive websites, and video interactive websites are some examples of call center services.

Call centers previously required a certain scale and type of business to justify their expense. Until very recently, telemarketing firms, catalog sales companies, and large customer service departments at banks, airlines, cablecos, and telcos have been the largest users of call center technologies. Indeed, these kinds of large retail businesses are starting to use increasingly sophisticated call center services at the high end of this market. However, the cost of software and equipment has fallen so that even small businesses can take advantage of the potential time and cost savings as well as the opportunity to serve customers better and faster than before.

To agribusinesses, call centers can mean the ability to avoid hiring extra employees to cover occasional busy spurts in average weeks or busy seasons. Call center services allow scarce personnel to avoid answering calls over and over regarding business hours, location, account balance, status of shipments, availability of sale merchandise or inventory. Phone system programming can provide premium customer service to large customers and attractive prospects, transfer delinquent accounts to collections, track employee telephone productivity, and display a customer's name and account information via computer the moment he calls (ScreenPop). Call centers can be particularly valuable in small businesses where employees are strapped to keep up with the workload, especially at peak hours. Customers also have access to account information, order status, hours, special offers and other information twenty-four hours a day, 365 days a year.

Table 4-19 shows some of the most important AIN CO technologies along with the call center services and PBX features those technologies support. Not all areas of Florida have access to these technologies because their availability depends on whether the ILEC has equipped the local exchange to support them. However, deployment does not depend solely on the ILEC as cablecos, electric utilities, ALECs, and wireless carriers are often able to provide enhanced services at a far lower cost than the ILEC can.

Table 4-19: AIN CO technologies advanced telephony features and call center services.

Item	Acronym or description	Level or Function
AIN	Advanced Intelligent Network	Group of technologies for ILEC COs or ALEC switches, carrier access and transport levels.
SS7	Signaling System 7	Access and transport levels.
Call center services	Inbound, outbound telemanagement, telemarketing	PBX system and telephone station services save time for customers & employees, save on telephone bills, ensure customer service procedures are followed, manage communications.
ACD & IVR	Automatic Call Distribution, Integrated Voice Response	PBX at agribusiness. Routes incoming calls through menu system, allows customer access to automated personalized information.
API	Application Programming Interfaces	PBX, Internet, & LAN interface at agribusiness.
Voice synthesis	Voice-to-text, Text-to-voice	CPE: conversion of voice mail to e-mail, e-mail to voice mail, certain IVR equipment, hearing impaired computing.
PBX system services	System-wide services for PBXs.	DID, FX DID, hunt groups, CDR & SMDR, least cost call (long-distance) routing, call pickup groups, predictive dialing, fraud prevention, voice mail.
PBX telephone station services	Advanced telephony features available in each telephone connected to PBX.	Caller ID, distinctive ringing, DID, FX, conference calling, call blocking, call waiting, call transfer, do not disturb, speed dialing, three-way and conference calling.

Savings of fifty percent per month on traditional services with many enhanced services available for free can result in telephone bills up to seventy percent below ILEC carriers for businesses who replace multi-line or Centrex systems with their own PBX. Additionally, the cost of a live telephone transaction (from $25-$35) can be halved using enhanced services-based call centers and cut to $3-$5 on web-based call centers [Sevcik and Forbath, 1999]. However, an agribusiness may need to have eight to twelve telephone lines before those savings can be achieved. Furthermore, some customers are likely to resent systems that make it too hard to reach a "real person", while others will prefer the convenience of not having to wait and the ability to call at any hour.

What follows is a thumbnail sketch of the technologies in Table 4-19. AIN is a term that applies to technologies used in the ILEC local exchange, CO switch, and transport network, including ALEC and cableco switch networks. Network intelligence is distributed under AIN. Therefore, new services can be quickly introduced, service customization is made easier, vendor independence and competition are aided, and open software and hardware interfaces are created [Telcordia, 2000]. AIN means these facilities are equipped with the software and hardware needed to support enhanced telecommunications services, LAN-based or CTI IP PBXs, and call center services.

SS7 is a protocol that enables advanced telephony features (see 4.5.2) through the access and transport levels. ACD and IVR systems were discussed in 4.7.1, as were APIs. Voice synthesis technologies perform voice-to-text and text-to-voice conversions when voice mail must be converted to e-mail, text e-mail converted to voice mail, or allows callers to speak responses to IVR or ACD prompts.

PBX system services have global inbound and outbound capabilities, meaning that they are based on the technology of the access trunks and ALEs (Access Line Equivalents). System services make it easier to perform telemanagement (manage costs, numbers, stations, and users). DID and FX DID are virtual telephone lines that are routed to specific extensions or departments within a business. Hunt groups transfer calls from unanswered or busy telephone *lines* to the telephone set of the next available group member. CDR (Call Detail Records) and SMDR (Station Message Detail Records) record call information such as length, cost, and extension so telemanagement tracking and fraud prevention can be performed.

Telemanagement reports can be prepared automatically to show long-distance charges, traffic to and from certain numbers or extensions, time on telephone per customer, etc. Least call long-distance routing allows the cheapest long distance carrier at a particular time for a particular call to be selected automatically. Pickup groups are sets of extensions that may be answered by anyone in a certain area. Predictive dialing is an outbound telemarketing service that allows computers to dial calls automatically and connect them to an operator once the call is answered by a human being.

PBX station services are advanced telephony features compatible with the PBX. These include such things as: caller ID, distinctive ringing, DID, FX, conference calling, call blocking, call waiting, call transfer, do not disturb, speed dialing, three-way and conference calling. When the services are purchased on a per trunk basis instead of a per line basis, costs can drop dramatically. Many ALECs and cablecos offer advanced telephony features at no additional charge to local customers in an attempt to woo customers from ILECs. The trunks used by modern PBXs may use dedicated and/or circuit-switched circuits to access the PSTN. The next sections cover access or the OSI physical layer used by enhanced telecommunications services.

4.7.3 Dedicated Circuits

Digital T-1 and ISDN are often both thought of as services and technologies. In reality, they both can function as physical layer (as defined in the OSI model, Figure 3-6) carrier connections that allow agribusinesses access to the PSTN, Internet, or their own private data network. Another dedicated circuit technology, SONET, is a special case since it can be more than simply a physical carrier. As will be shown in 4.7.4, ISDN has such a broad definition that it can be hard to pin down an exact meaning except in context. The main difference between the dedicated circuits covered in this sub-section and the circuit-switched circuits of 4.7.4 (such as ISDN) is that dedicated circuits are not circuit-switched through telco voice switches.

The dedicated circuits shown in Table 4-20 have several things in common with respect to enhanced telecommunications. First, dedicated circuits are leased from an ILEC or ALEC for the sole use of an agribusiness and are available around the clock 365 days each year. Second, they are point-to-point circuits that travel between agribusiness locations (or from an agribusiness to a provider's POP). Typically, dedicated circuits use telco access and transport networks, but do not travel through CO switches.

Hence, in addition to avoiding congestion with PSTN traffic, dedicated circuits avoid the chance of poor connections and other vagaries connected with POTS switches. Most dedicated circuits are "always-on" so there is no connection establishment delay or connection establishment failure. Other QOS variables can be controlled better by carriers since dedicated circuits are engineered to be resilient enough that failure probabilities are extremely low. Charges are a flat monthly fee based on constant use of the entire circuit capacity, whether it is actually used or not. Dedicated circuits that cross LATA boundaries are more costly than inter-LATA dedicated circuits if an ILEC provides them.

There can be significant costs if an agribusiness switches from one carrier to another (but keeps the same type of circuit) or if it switches from one dedicated circuit to another. Such switching costs occur because contracts typically offer the lowest rates the longer the agribusiness is obligated. One to five year terms with a particular carrier at a set price are common. Even if prices fall or new lower-priced carriers begin to serve an area, the agribusiness is obligated by the contract. Furthermore, in many cases, the CPE purchased for use with one carrier's identical service offering will be incompatible with that of another carrier for technical reasons or because carriers make alliances with CPE manufacturers.

Changing from one type of dedicated service to another or adding to existing service (because of business expansion or new needs, etc.) can mean costly rewiring and installation charges and the purchase of new CPE. Service switching costs can even include installation charges for access loops and DCE in the loop such as repeaters or amplifiers, a fact remotely located businesses are already aware of. Thus, networks must be planned carefully with dedicated circuits because capacities must be correctly estimated.

Table 4-20: Dedicated circuit services (voice and mixed voice-data).

Circuit	Traffic	Voice capacity	Bandwidth (Code)	Data capacity
Dedicated analog voice grade line.	Analog voice or modem data.	Non-switched leased line from one point to another.	4 kHz (NA)	Modem capacity up to 33.4/56 kbps
DS-0 dedicated digital line or lines (fractional T)	Voice trunk, voice-data mix possible.	Varies by compression, overhead. Typically, 1 digital circuit (voice or data) per 56-64 kbps.	8-40 kHz (PCM)	56-64 kbps per circuit, symmetric.
DS-1, T-1 digital carrier	Voice trunk, Internet, data.	24 channels @ 56 or 64 kbps per digital line.	1.544 MHz (AMI) 2.316 MHz (B8ZS)	1.536 Mbps, symmetric.
DS-1, T-1 (HDSL feeder)	Voice trunk or voice-data mix (Smart T).	Fewer than 24 channels when shared with data.	420 kHz (2B1Q)	1.536 Mbps, symmetric
DS-3, T-3	Multiple voice trunks or voice-data mix.	672 voice channels or mix of voice, data.	67.145 MHz (B3ZS)	44.736 Mbps, symmetric.
DSL	Voice-data mix or data only.	0 to many, depending on variety. (See Table 4-21)	1110 kHz (ADSL)	Differs by DSL variety.
Cableco modem & phone	Internet, enhanced telephony, VPN.	1-3 lines, new technologies may permit more.	360 MHz (QAM, QPSK)	30 Mbps downstream (shared), 768 kbps upstream
SONET self-healing ring	Fiber optic data & multiple voice trunks.	Varies by OC level & compression: 1,000 (OC-1) to 150,000 (OC-192).	To 1 GHz (WDM, DWDM)	Varies by to OC level, OC-1 51.84 Mbps.
Wireless dedicated Ts	Voice, data, or mix.	Varies by service, carrier, and distance.	Varies	Varies

Sources: Tower, 1999; FitzGerald and Dennis, 1999, Hill Associates, 1998.

Analog voice grade dedicated circuits (the first item in Table 4-20) are traditional POTS lines that carry analog voice or data via modem from one point to another over a non-switched route dedicated to the subscriber. Analog leased lines are charged monthly on a per line basis with one voice grade line the usual unit. They may be used for voice intercoms, telephones, or to connect computers at two locations using ordinary modems. Dedicated analog voice grade circuits are also used to connect agribusinesses with ISPs for dedicated Internet connections, links for POS devices, or for remote sensing. The circuit may be open at all times or require connection establishment depending on CPE. Channel bonding is a technology that may be used to combine the bandwidth of two (or more) dedicated analog circuits to create faster data rates and better throughput. However, each end of the connection must have a channel bonding capable modem.

The remaining dedicated circuits are digital. The DS (Digital Signal) hierarchy governs how the next four dedicated circuits in Table 4-20, DS-0, fractional T, T-1 (DS-1), and T-3 (DS-3) are sold. The first DS hierarchy, DS-0 or fractional T circuits, are sold in increments of 64 kbps by ILECs and ALECs. DDS (Digital Data Service) is the name of telco offerings for single 64 kbps circuits. Voice, data, or a voice-data mix may be carried on a single DDS point-to-point line. However, DDS (as the name implies) circuits normally carry data networking or Internet traffic. A CSU/DSU is needed at the customer premises.

T-1 and T-3 dedicated circuits are called T carriers to emphasize the fact that, technically, they are technologies used to carry services. Services such as ISDN-PRI, frame relay, SMDS, ATM, and the Internet may be carried via Ts. However, they are also sold as point-to-point connections for other services such as links in private data networks or for voice telephony use. Typically, voice Ts are switched ISDN-PRI circuits (covered in 4.7.4), but it can often be hard (and sometimes unnecessary) to distinguish T-1s from the voice or data services they carry.

T-1s previously were so expensive that only large corporations could afford them. Hence, fractional Ts (groups of 64 kbps channels such as 128 kbps, 256 kbps, etc.) were introduced for the small business market. Now prices are as low as $100 per month for fractional Ts and even full T-1s are priced from $500 to $1200 per month. Therefore, smaller firms can often save the full monthly cost of the T when they switch from multiple single lines to fractional T-1 or T-1 trunks.

Some IXCs offer dedicated fractional Ts from the agribusiness to the long-distance POP for as few as eight lines, avoiding local service line charges as a full T-1 does, but for much smaller businesses. With a long-distance fractional or full T, long-distance calls are routed directly to the long-distance carrier without having to pay for local loop charges on these lines. Fractional Ts can be used to connect frame relay equipment to other locations in the company WAN or to ISPs. Typically, only one telephone conversation per 56-64 kbps channel can be carried. However, if a voice compression technology other than standard PCM is used, more conversations can be handled in a single channel. Upgrades to full T-1 leased circuits usually involve changing edge devices, but are not likely to require installation fees from the ILEC or ALEC if fractional service has been established.

T-1s transmit point-to-point DS-1 (1.544 Mbps) signals (which carry voice or data or combination traffic) from one point to another. Typically, separate T-1 carrier lines are used for local telephony trunk lines, intra-LATA long-distance trunk lines, inter-LATA long-distance trunk lines, and DID or DID FX trunk lines. Since T-1s feature in-band signaling, each T-1 trunk has 24 channels for individual telephone conversations. Voice-only T-1s are access level connections to local telephone switches of ILECs or ALECs, or to long-distance IXC POPs. Data-only T-1s serve as dedicated links in WANs or as dedicated links to ISPs from an agribusiness location with data rates of 1.536 Mbps. Some Ts (smart Ts) can be used to combine various voice, data, and Internet services in one T. Local T-1 service is available in some areas from cablecos, wireless carriers, and directly on optical fiber networks of IXCs or ALECs. Voice T-1 service differs from ISDN-PRI voice service (carried at T-1 speeds) because switching is not done through the ILEC's voice switch. Often, what is sold as a voice T-1 is technically an ISDN-PRI.

There are several T-1 carrier technologies: AMI/B8ZS, 2B1Q/HDSL T-1, and CAP/HDSL T-1. Before considering what these acronyms stand for and why the type of T-1 carrier technology is important to agribusinesses, realize there are differences that go beyond the three varieties shown in Table 4-20. T carriers differ according to framing, signaling, timing, and whether clear channel capability and customer reconfiguration control (smart Ts) are offered.

Framing concerns the order in which bits and overhead information (signaling) are sent [Hill Associates, 1998, p. 303.2.6]. Framing reduces the usable part of a T-1 circuit to 1.536 Mbps. Two different kinds of framing, SF (Super Frame) and ESF (Extended Superframe) are available. ESF allows both the agribusiness and the telephone company a superior ability to diagnose problems with T-1 lines that otherwise can go undiagnosed for weeks.

The kind of signaling technology affects the circuit's capacity and may determine whether CPE will be compatible with the carrier's hardware and software. Out-of-band or ZCS (Zero Code Suppression) signaling used is with ISDN-PRI (4.7.4), so one of the 24 channels in those circuits carries information about the status and operation of each of the 23 remaining user channels. In-band T-1 signaling lets all 24 voice channels be available to subscribers. Robbed bit in-band signaling (used with voice Ts) allows signaling information to travel over the same channels voice calls do by "robbing bits" from the voice call without affecting call quality [Hill Associates, 1998, p. 303.2.11]. Dial tone, ringing, caller ID, and toll and billing data are examples of voice signaling data.[35]

Timing technologies synchronize bits, maintaining sending and receiving flow control. These background technologies matter to agribusinesses because they determine the distance from CO (or RAV) to customer premises that a T-1 circuit is capable of reaching in addition to the cost of providing the line.

Each T-1 technology has other important differences such as differences in line coding or modulation. The next two figures show the frequency ranges of four different T-1 technologies (AMI, B8ZS, 2B1Q HDSL, and CAP T-1 HDSL). Since each technology has different bandwidth requirements, their ranges vary. Figure 4-43 shows the first part of this relationship, the bandwidth requirement.

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[35] Signaling is not a synonym for communications signal. Instead, signaling is considered overhead that helps identify, route, and track the billing of communication signals.

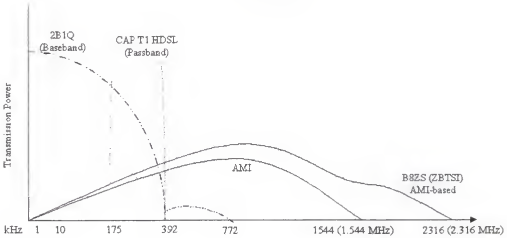

Figure 4-43: Bandwidth used by various T-1 and DSL T-1 technologies.

The first T-1 technology, AMI (Alternate Mark Inversion) Ts require expensive repeaters to be spaced 2000- 6000 feet apart over the full length of the loop. Additionally, AMI lines are so noisy that only one may be carried per bundle of 50-100 telephone lines to any one area, making installation difficult in areas where multiple T-1s are to be deployed. B8ZS (Bipolar with Eight-Zero Substitution) supplanted AMI as the most popular line code for T-1 transmission in many areas by the 1990's. B8ZS is AMI with ZBTSI (Zero Byte Time Series Interchange), a method that provides a clearer channel and better timing than AMI. However, standard AMI requires 1.544 MHz of bandwidth (and B8ZS needs 2.316 MHz) which can be a problem because attenuation is greater at higher frequencies.

As can be seen in Figure 4-44 [Adapted from Paradyne, 1999, p.15], B8ZS improved on AMI's range without repeaters. While AMI could reach 6,000 feet, B8ZS AMI could go to just past 13,000 feet. However, note that 2B1Q and CAP (as used in less-costly DSL) transmit 1.536 Mbps for 12,000 and 18,000 feet (respectively) without expensive repeaters or special DCE, as are required with B8ZS. This is primarily due to their efficiency in bandwidth use (as shown in Figure 4-43).

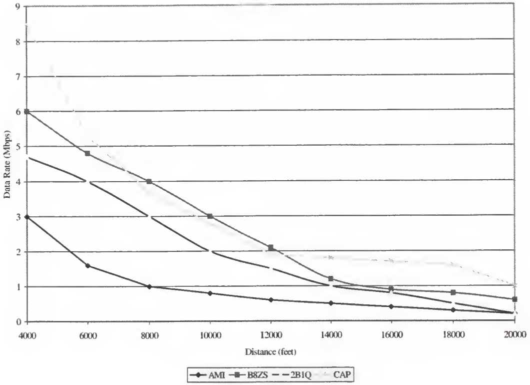

Figure 4-44: Range of various T-1 line codes.

Repeaterless HDSL feeder T-1s such as 2B1Q and CAP are better able to support smart T technology, and less expensive to deploy because repeaters are not needed within 12,000-18,000 feet of the CO. Over 70% of digital Ts now deployed are actually another type of dedicated circuit with superior range, a form of DSL called HDSL [Orckit, 2000] to be covered after T-3 dedicated circuits are mentioned.

T-3 carrier circuits have 28 times the capacity of T-1s. They are generally less expensive than buying from 10 to 15 T-1s separately. T-3 dedicated circuits operate in much the same way as T-1s, though they are mainly deployed over fiber optic lines rather than quad copper unless service is to be provided near the CO or special high-powered repeaters are used. The only way around installation of fiber optic cable for T-3 connections is via a point-to-point microwave path.

Because of the size and capacity of T-3s, there are few agribusinesses with the communications scale needed to demand a full T-3. However, an agribusiness that hosts its own website, owns over a hundred computers (requiring Internet and data network access), and requires as few as one hundred telephone lines could find that it would save money with a converged T-3 connection. By purchasing a single connection, the business would save compared to the cost of paying for separate local trunks, long-distance trunks, and Internet and data connections. Fractional T-3 carriers are also offered.

T-3s with customer reconfiguration control (smart Ts) are perhaps the only current possibility for most agribusinesses other than fractional T-3 connections. A voice-only full T-3 carries 672 voice channels, far beyond the needs of all but large corporations. DCSs (Digital Cross-connect Systems) allow multiple services (various voice trunks, data, and Internet) to be carried over a T-3 between multiple agribusiness locations, sometimes using more than one carrier. However, a smart T-3 connection can take expensive equipment and considerable design and planning. In many cases, telcos design smart T-3s that are somehow not smart enough to be cross-connected with competitors, forcing one-stop shopping for multiple services.

Because they rely on existing copper wire, DSL (Digital Subscriber Line) technologies may be an excellent way for rural Florida residences and small Florida agribusinesses to acquire access to high-speed hypercommunication services. The ILEC's own facilities and existing copper wires are used to deliver voice, data, and Internet service using several DSL technologies. However, the provision of DSL services is highly sensitive to the distance between the subscriber and the serving CO. In some cases, wire centers and RAVs (Remote Access Vehicles) have been implemented that bring DSL closer for customers who are farther than 18,000 feet from a CO. However, DSL faces several technical barriers based on the ILEC wire plant. These barriers include loading coils (used often on longer local loops), bridged taps, and DSL incompatible RAVs. These were discussed in 4.3.2.

Table 4-21 lists twelve varieties of DSL. The full translation of each acronym, bandwidth in Hz (where available), maximum data rate, and maximum range are also shown. For several reasons, the sources used to prepare Table 4-21 showed enormous variability concerning the capabilities of DSL varieties. First, information changes from month to month as new technologies are rolled out and from region to region depending on how local carriers deploy DSL. Second, carriers offer levels of service that include hierarchies of bandwidth for most forms of DSL. For example, BellSouth's FastAccess™ ADSL is 1.5 Mbps upstream and 256 kbps downstream, while GTE's ADSL goes from a bronze level (256 kbps/64 kbps) to a platinum level (1.5 Mbps/768 Kbps). While most DSL CPE operates at several speeds, there can be CPE incompatibilities among line codes or modulation methods. Finally, differences in DSL technologies are responsible for divergent claims regarding the superiority of standards.

Hence, before discussing the varieties of DSL shown by Table 4-21, the problem of comparing different standards with each DSL variety must be briefly addressed. For example, the ANSI and ITU ADSL standard modulation is time domain DMT (Discrete Multi-tone), while Paradyne (formerly part of AT&T) uses a frequency domain CAP (Carrierless Amplitude and Phase Modulation) scheme licensed from GlobeSpan Technologies, Inc. The debate among supporters of these two standards has been particularly contentious.

Both CAP and DMT modulate the upstream and downstream signals into frequency bands using passband modulation techniques. CAP is a DSL modulation based on QAM (Quadrature Amplitude Modulation). As shown in Figure 4-45 on the right, CAP allows the DSL signal to occupy the full bandwidth, splitting transmissions up by time in modulation, similar to TDM. DMT is a DSL technology that uses DSPs to divide the signal into 256 sub-channels of 4 kHz as shown on the left of Figure 4-45 [Schneider, 1999].

However, CAP is a *de facto* but not a *de jure* standard. Regardless of CAP's standards status, it is used by many telcos for ADSL [Schneider, 1999]. DMT (Discrete Multi Tone) is the *de jure* ANSI/ITU ADSL standard in competition with CAP. DWMT (Discrete Wavelet Multi-

Tone) is Aware Inc.'s *de facto* standard designed to be superior to regular DMT. According to Aware, "DWMT is able to maintain near optimum throughput in the narrow band noise environments typical of ADSL, VDSL, and Hybrid Fiber Coax, while DMT systems may be catastrophically impaired." [Aware, 1999, p. 8]. DWMT is used for VeDSL.

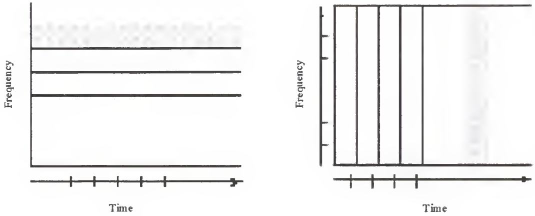

Figure 4-45: DMT (left) and CAP (right) are two competing ADSL standards.

Several line codes are used for specific DSL varieties. Baseband line coding schemes such as 2B1Q (Two Binary 1 Quartenary, four-level code compresses to binary bits into one time state) are used to provide IDSL and HDSL. OPTIS is used for HDSL2. Most DSL transceivers (also called DSL modems) use either CAP or DMT, while others can only be set for the standard supported by the carrier. In addition to a DSL modem, an NIU (Network Interface Unit, or splitter) is needed as an edge device to connect to the local copper access loop.

All kinds of DSL (x-DSL is used to describe DSL service of an unknown or generic type) operate in several distinct frequency ranges in order to separate upstream DSL, downstream DSL, and voice signals. Figure 4-46 shows how frequencies are used in ADSL.

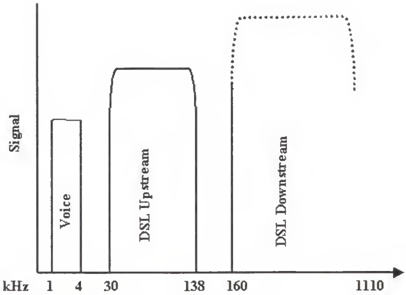

Figure 4-46: ADSL frequency channels.

The voice channel for a single telephone line operates from 0 to 4 kHz. A guardband (4 to 30 kHz) separates the voice band from the DSL upstream signal that occupies 30 to 138 kHz. Another guardband (138 to 160 kHz) separates the downstream that occupies from 160 kHz and runs to 1104-1110 kHz depending on the distance to subscriber and service level offered. The precise DSL frequencies used vary by line code, distance, and the spectral compatibility of other services (such as ISDN and HDSL T-1) that may share access distribution cable. Guardbands prevent interference between voice, upstream, and downstream DSL signals.

Just as was true for T-1s, higher DSL frequencies bring higher interference levels, especially if wires are above ground on telephone poles between the customer and CO. However, to increase the data rate in any direction, the larger slices of spectra are needed. Since DSL is a repeaterless technology (that uses existing copper access loops), it works better the shorter the distance from subscriber to CO. The same relationship between bandwidth, maximum frequency, and interference levels that governs T-1s is an important reason distance plays such an important role in DSL availability. The symmetry depends on the bandwidth of each direction's slice of spectrum, but lower frequencies are able to carry far more data than higher ones. It is for this reason the analog voice line is absent from some DSL varieties such as G.Lite, IDSL, and HDSL2.

ADSL (Asymmetric DSL) is the most frequently deployed variety of DSL by ILECs in Florida and is the first entry in Table 4-21. Indeed, there is an entire family of asymmetric DSL services including ADSL, MDSL, G.Lite (UDSL), CDSL, and RADSL as well. All five have two things in common: asymmetric bandwidth and ability to carry a single telephone line. Developed at Bellcore beginning in 1989, ADSL is asymmetric with maximum upstream rates of 640 kbps and downstream rates varying from 1.5-8 Mbps depending on distance, condition of the copper loop, and local CO capacities. ADSL (DMT) operates from 0 to 1024 kHz or 0 to 1110 kHz with voice POTS.

In 1999, an ITU *de jure* G.Lite (or splitterless DSL) standard was formally approved. G.Lite is like ADSL except that it does not require a visit to the customer to install a splitter that separates voice and data circuits on the customer premises. Splitterless DSL is more convenient for the carrier since a service visit to the customer location (truck roll) is not required to install a splitter (NIU). However, with a splitterless DSL, some sacrifice in speed is needed and only one telephone jack will be DSL equipped.

CDSL (Consumer DSL) is a splitterless proprietary standard developed by Rockwell that uses a proprietary transmission technology instead of DMT or CAP ADSL technology. Like G.Lite, it is splitterless (neither variety allows an analog POTS line), but CDSL has a shorter range and slower data rate than G.Lite does. By 2001, four times as many splitterless DSL circuits are expected to be deployed in the U.S. residential market than all DSL circuits with splitters. RADSL is a rate adaptive form of DSL that adjusts the data rate to subscriber distance from the CO rather than supporting a uniform rate through the entire area.

Table 4-21: Varieties of DSL services.

Type	Full name	Bandwidth (Hz)	Maximum data rate		Maximum range: CO to user in feet, for (line code)
			Upstream	Downstream	
ADSL family (Asymmetric)					
ADSL	Asymmetric DSL (1 loop)	0-4, 26-138 &138-1110 kHz (DMT)	640-768 kbps	1.5-8 Mbps	(DMT) 18-24,000 (1.5 Mbps), 6,000 (7 Mbps)
MDSL	Medium bit rate DSL	Varies	100 kbps	800 kbps-1 Mbps	22,000
G.Lite-UDSL	DSL Lite, Universal DSL (splitterless)	0-4, 26-138, 138-550 kHz	64-512 kbps	1.5 Mbps	(DMT) 22-25,000
CDSL	Consumer DSL (1 loop, splitterless)	Varies	128-384 kbps	1 Mbps	12-18,000
RADSL	Rate-adaptive DSL (1 loop)	0-128, 0-800 kHz	Adapts to 1 Mbps	Adapts to 8 Mbps	(CAP) 18,000 (1.5 Mbps), 6,000 (7 Mbps)
VeDSL (Multiple voice lines)					
VeDSL	Voice-enabled DSL (multiple phone lines)	0-1110 kHz	64-512 kbps	1.5 Mbps	22-25,000 (DWMT)
HDSL family (symmetric)					
HDSL	High data rate DSL (2 loops)	175-393 kHz	1.5 Mbps	1.5 Mbps	12,000 (2B1Q)–18,000 (CAP)
HDSL2	High data rate DSL (1 loop)	0-420 kHz (OPTIS)	1.5 Mbps	1.5 Mbps	18,000 (CAP), 22,500 (384 kbps)
SDSL	Single Pair DSL (1 loop)	175-393 kHz	260-784 kbps	260-784 kbps	12,000-20,000
MSDSL	Multi-rate symmetric DSL (1 loop)	175-393 kHz	1.5 Mbps	1.5 Mbps	(CAP) 21,000 (768 kbps), 29,000 (128 kbps)
IDSL	DSL with ISDN overlay, (1 loop)	0-80 or 0-120 kHz (2B1Q)	144 kbps	144 kbps	26,000 (2B1Q)
VDSL (fast copper, FTTN)					
VDSL	Very-high data rate DSL (1 loop)	300-20000 kHz	1-20 Mbps, ver. 5	51.8 Mbps, ver. 5	984-4,500 (DMT)

Sources: FCC, 1999, p.21; Schlegel, 1999; Tower, 1999, p. 9-6, Paradyne, 1999, p.24, Weinhaus, 1998, Sheldon, 1998, pp. 312-314, Aware, 1999, 2000, Orckit, 1999, p. 5, Rhythms, 1999, p.2; Zimmerman, 1998, p.33.

The next two version of DSL allows multiple voice lines over the same copper wire that carries DSL into the customer premises. Some DSL circuits (such as HDSL2) do not carry PSTN telephone conversations. Those DSL varieties that carry PSTN calls are usually designed for a single telephone line, but it is expected that future IDSL implementations will carry two lines. VeDSL is a new technology (developed in 1999) that allows two or more telephone lines to work in conjunction with DSL, using voice compression and other techniques. However, the symmetric HDSL family (to be covered next) will soon join the category of the multiple voice line DSL family. When that occurs, trunk line prices may fall to one-tenth of their T-1 levels and one-third of their ISDN-PRI levels. Additionally, if special voice compression CPE is installed, from 44 to 148 telephone calls may travel simultaneously over one HDSL connection, even while data traffic obtains rates from 325 to 1181 kbps as well [Henderson and Lipp, 2000, p.13]. Currently, other DSL varieties support one analog voice line or no voice service at all.

As Table 4-21 shows, the symmetric DSLs in the HDSL family include HDSL, HDSL2, SDSL, and MSDSL. HDSL (developed by Bellcore and Bell labs in 1986) uses quad copper and the 2B1Q (4-PAM) line code that ISDN and IDSL use. HDSL can transmit symmetric T-1 signals without the need for repeaters every two to six thousand feet as with AMI, reducing costs and cross talk in the process. HDSL2 requires only a single wire pair rather than quad, allowing repeaterless T carrier signals to travel over one pair for up to 18,000 feet. HDSL2 does not offer a voice line as HDSL does, but is used as a replacement technology for AMI and B8ZS T-1 dedicated circuits. HDSL2 uses a high efficiency line code (OPTIS or 16 PAM). T-1 implementations using repeaterless HDSL need to be within 12,000 feet of the CO with 2B1Q or 18,000 feet with CAP. However, installation of a fractional HDSL T-1 (with 768 kbps speeds) is possible within 36,000 feet of a CO if doublers (special DSL repeaters) are used [Zimmerman, 1998, p. 46]. Currently, HDSL is used mainly as a separated T-1 connection for voice or Internet or data networking. However, a powerful and flexible converged version (able to combine traffic types) will shortly be available [Henderson and Lipp, 2000]

SDSL was developed before HDSL2 as a single wire pair solution with symmetric data rates. SDSL allows a single voice line while most HDSL implementations do not allow voice transmissions. SDSL allows static IP addresses (important to Internet applications), while ADSL usually uses dynamic IP addresses. MSDSL is a proprietary DSL protocol form of SDSL. It allows rates of 128 to 1024 kbps within 11,500 feet [Schneider, 1999].

IDSL is an ANSI DSL standard developed in the 1980's mainly so modem calls could be removed from switched PSTN. The idea was to prevent congestion of the telephone network by data calls (which are on average longer) so the RBOCs could avoid increasing the size number of simultaneous switched PSTN connections. IDSL does not require expensive circuit-switching gear to be deployed at the telco CO as ISDN does because IDSL does not require connection though a circuit-switched voice switch as ISDN-BRI does. IDSL can be deployed over all kinds of RAVs and DLCs, the only DSL with such flexibility.

However, in areas where ISDN is already deployed IDSL may be deployed at a very low cost regardless of the type of fiber-copper RAV that may be present. Other forms of DSL cannot be implemented over certain SLC-RAV combinations. IDSL uses the 2B1Q line code as the modulation scheme. Current versions of IDSL support data rates of around 144 kbps, similar to ISDN-BRI. IDSL may become more widely available with ISDN-PRI variants of HDSL or HDSL2 that allow a fully symmetric 1.544 Mbps ISDN-PRI connection that will allow ten to twenty voice lines [Schneider, 1999].

The last variety of DSL is VDSL. VDSL (developed in 1995) can use QAM to achieve data rates of up to 2 Mbps downstream and over 50 Mbps upstream within a few thousand feet of a CO. Because of its short range, VDSL deployments are limited to areas near COs or to those areas with hybrid copper-fiber infrastructures such as FTTC or FTTN. VDSL has by far the fastest data rates of any DSL variety with the shortest range. VDSL is not yet widely deployed.

The monthly cost of DSL ranges from one-third to one-twentieth the cost of fractional T or T-1 circuits with similar bandwidth.[36] Often, however, as Table 4-21 shows, DSL will have asymmetric upstream and downstream rates while other dedicated circuits (such as T-1s) are symmetric. Asymmetric services (ADSL, G.Lite, IDSL, VDSL, and CDSL) are mainly intended to allow simultaneous PSTN and Internet access. Hence, DSL is often used for data (VPN, Virtual Private Networks, 4.9.7) or Internet access (4.9.1) for SOHO or small business applications.

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[36] Pricing is discussed in more detail in 6.4.2.

Figure 4-47 shows how DSL is deployed [BellSouth, 1998]. An Ethernet card and Ethernet cable goes from the CPE DTE (computer) to a DSL modem and then to a splitter attached to a splitter or NIU (Network Interface Unit) at the demarcation point on the customer premises. The splitter separates telephone and data traffic at the agribusiness. In the BellSouth model, the NIU is connected to the CO via a conditioned copper loop. Upon arrival at the CO, POTS voice traffic travels through a voice switch and on to the PSTN while data traffic through a DSLAM (Digital Subscriber Line Access Multiplexor). The DSLAM combines signals from all DSL connections in an area and forwards them to an ATM switch and routes them to the Internet (via an NSP/ISP) or private WAN.

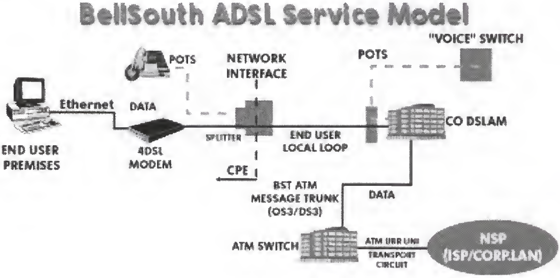

Figure 4-47: BellSouth's ADSL Service Model.

To a certain degree, DSL is an evolving technology that is still seeking a market. The ADSL family is suited to SOHO or small farm applications, especially for the Internet and voice line combination. DSL can be provided at distances of up to 25,000 feet from COs either by ILECs or by specialized DSL ISP/ALECs such as Rhythms and Covad. ILECs allow such DSL competitors to provide service in some areas of Florida because DSLAMS and line conditioning are expensive and cannot proceed simultaneously throughout Florida. The ability of alternative DSL carriers to provide service to an area depends on the ILEC's infrastructure design and co-location policies, since the competitor has to install a DSLAM at the CO to provide service.

VeDSL has great market potential, but is likely to be eclipsed by HDSL (or new IDSL PRI-style) circuits capable of serving as converged networks. At present, HDSL is mainly being sold as a technologically superior version of a T-1 carrier. HDSL2 is expected to replace data-only HDSL so that it will be more widely deployed since only one wire pair is needed. Meanwhile, advanced HDSL circuits will offer businesses the data networking benefits of T-1 dedicated circuits and the ability to use the office PBX to support enhanced voice as currently ISDN-PRI does.

Before moving on to circuit-switched digital connections in 4.7.4, three other dedicated circuits need to be mentioned. The first of these is cable modem and telephony service. However, since they use broadband signaling (and are shared with as many as 5,000 other users on a node), cable modem connections are not dedicated in the same way a T-1 or DSL is. However, data connections over cable share the lack of connection establishment delay and the high speeds of other dedicated connections, while cable prices are dramatically lower than T-1s or many kinds of DSL. Cablecos throughout Florida are rushing to deploy hybrid coax-fiber infrastructures (see 4.3.3) capable of supporting digital cable TV, two-way Internet access, and enhanced telephony. Cableco offerings are aimed primarily at the residential market in cities, towns, and suburban unincorporated areas for several reasons.

The first reason cableco dedicated circuits are aimed at the residential market is that demand for Cable TV is mainly found in the home rather than office. Second, while cable modems offer data rates that rival T-1 speeds, cable modems are shared connections so that as service becomes better utilized, speeds could decrease. Furthermore, there are security problems inherent in creating business data networks over a shared broadband pipe along with a shortage of CPE that would support more than two or three computers at a location served by cable modem service. The telephony offerings of cablecos, while price competitive (most enhanced services are far cheaper than they are when purchased from ILECs or ALECs), are hobbled by the asymmetric nature of the cable network. Most systems do not have the upstream capacity necessary to support more than one to four telephones per location.

Small agribusinesses located in small towns or suburban areas may find cable-provided voice to be a better buy than telco offerings. Over the same connection, high-speed cable Internet is a bargain when compared to other always-on dedicated connections. The cablecos are busy rolling out residential service. Once the cable industry begins to focus on business (currently a secondary market), expect to see new varieties of CPE, more truly dedicated circuits, and the ability to support many telephones over a single trunk.

SONET or synchronous optical networking can be another example of a dedicated circuit. SONET is unique among dedicated circuits because it often features self-healing rings (route diversity) so that even if a fiber is cut service is not interrupted. SONET requires a physical connection to a fiber optic network. Like a T-3 carrier, SONET is a carrier circuit able to transmit data and multiple voice trunks. The bandwidth of a fiber optic cable (up to 1 GHz) can support numerous voice circuits. The number of telephone lines varies from 1,000 voice channels on an OC-1 to over 150,000 on an OC-192, according to the OC level and the compression technology. Similarly, data rates vary by OC level. An OC-1 SONET carrier circuit is capable of carrying 51.84 Mbps, while an OC-192 can carry 9.953 Gbps. SONET is used to carry service ranging from enhanced voice telecommunications to data networking and Internet access. Currently, SONET requires a large business scale to take advantage of its speed and versatility and a business location on or near a carrier's fiber backbone. Since SONET supports data networking applications and services in addition to enhanced telecommunications services, it is covered in more detail in 4.8.4.

Wireless technologies are also capable of carrying most of the dedicated circuits mentioned here. Already, some more remote locations have T-1 or T-3 connections via microwave links. As was mentioned in 4.4, a variety of wireless technologies (such as LMDS, MMDS, DEMS, and WLL) are capable or soon will be of providing fixed dedicated circuits up to T-3 speeds.

4.7.4 Circuit-Switched Digital Connections

"Circuit-switched digital connections" refers to digital traffic that is circuit switched through the ILEC CO (or ALEC switch) rather than a point-to-point dedicated circuit. The most important circuit-switched digital circuit is ISDN-PRI used to carry 23 voice channels between a business PBX and the PSTN, though ISDN-PRI can also support switched data circuits.

Circuit-switched services have several advantages over dedicated circuits. First, firms pay only for the bandwidth they need, for the time they need it. Unlike dedicated circuits, circuit-switched services often allow bandwidth on demand, giving the customer the ability to tailor capacity to changing needs rather than fit business needs to a static capacity. However, circuit-switched circuits have connection establishment delay and the possibility of connection establishment failure, which is unheard of with dedicated circuits.

Table 4-22 lists the main circuit-switched digital services. ISDN dominates the list of circuit-switched services. Used here, IDSN has a specific definition: an end-to-end circuit-switched digital connection (with out-of-band signaling) capable of carrying 23 voice channels or data in multiple channels. ISDN uses a CSN (Circuit-Switched Network) that creates on-demand (rather than dedicated) physical circuits. When a digital ISDN telephone is taken off hook, that circuit is reserved for the user until it is hung up (if a circuit is available). ISDN is available in two forms: BRI (Basic Rate Interface) and PRI (Primary Rate Interface).

ISDN-BRI offers two 64 kbps B channels usable either as telephone lines or as Internet or data connections. ISDN-BRI had (at one time) been expected to surpass the modem in popularity, but because of slow ILECs deployment and the tendency for circuit-switched services to have per-minute charges, ISDN-BRI never became a popular method of Internet access. An NT1 is an edge device needed on the customer's premises to connect to the digital telephone line used to carry ISDN signals. Up to eight ISDN compatible devices including fax machines and digital telephones, can be connected to the BRI circuit. While the two B channels can support a maximum of two telephone calls at once, multiple calls can be put on hold using D-channel signaling (multiple call appearances). Analog telephones require special adapters to be used with either form of ISDN, though a PBX can serve as both the adapter and the NT edge device (NT2) with ISDN-PRI. To deploy ISDN, ILECs use standard twisted copper pair, but must use ISDN signaling, install special CO equipment, buy DMS-100 or 5ESS switches, and condition lines longer than 15,000 feet [Eichon, 1996].

Table 4-22: Circuit-switched digital services.

Service	Bandwidth (data rate)	Range
ISDN-BRI	0-50 kHz, 0-80 kHz (128 kbps)	26,000 (2B1Q) to 36,000 feet (via IDSL)
ISDN-PRI	0-772 kHz (Up to 1.52 Mbps)	15,000 feet, longer with repeaters
Early ISDN-BRI (AMI)	0-180 kHz (To 1.472 Mbps)	Far short of 18,000 feet
Switched 56	0-50 kHz (56 kbps)	26,000 feet
Switched 64	0-50 kHz (64 kbps)	26,000 to 36,000 (with repeaters)

Sources: Paradyne, 1999; Eichon, 1996; Rythms, Inc. 1999.

ISDN-PRI is the main ISDN service deployed today in Florida, featuring 23 64 kbps B (Bearer) channels and one 64 kbps D channel used for signaling. Usually, only one DCE device (such as a PBX) can be directly connected to the ISDN-PRI circuit. Hence, ISDN-PRI is often used for offices equipped with PBXs since a PBX can switch calls made over the 23 B channels onto separate telephone connections in the office. Some ISDN implementations (depending on carrier and location) allow specialized joint data-telephony use of the circuit where bandwidth can be dynamically allocated between data and telephone calls. Once a telephone call is finished that channel's bandwidth can be added to a data transmission or Internet connection. However, when an office telephone rings or a call needs to be placed, data transmission is automatically reduced so the B channel can carry the call. While ISDN-PRI can be used for WAN connections and limited packet-switched data applications, the primary business use is in enhanced telephony.

Voice use predominates because ISDN is compatible with SS7 signaling and AIN CO technologies so that it is often used for call center and CTI applications. ISDN-PRI supports the full range of enhanced telephony services so that business PBXs have system and station features such as caller ID, three-way calling, etc. without having to pay for them on multiple lines. ISDN-PRI is also used for video conferencing and Internet access. Using an inverse multiplexor, B channels can be combined, and all the bandwidth allocated to one application.

The delivery capabilities for rural Florida vary by ILEC and type of ISDN service. Because ISDN tariffs include monthly fixed charges and metered or measured tolls, ISDN can be an expensive way to obtain a mix of Internet access, voice, and data communications, especially for rural agribusinesses. However, so-called ISDN Ts (actually ISDN-PRI connections dedicated to telephony) are popular ways for medium sized businesses to get T-1 speeds without having to purchase separate dedicated circuits for long-distance and local telephone service.

Another kind of circuit-switched digital service is Switched 56, a CSD (Circuit-Switched Data) technology where a circuit-switched 56 kbps data call where a circuit is established between two users as long as desired at a constant rate. Unlike a 56 kbps modem, Switched 56 service offers a symmetric 56 kbps bandwidth for data connections between parties with compatible equipment. Switched 56's main advantage is that it is usable on demand, without paying for a dedicated line. Switched 64 circuits are also available.

4.7.5 Enhanced Mobile Telecommunications: Digital Cellular and PCS

As has been discussed in 4.4 (the wireless technologies section), cellular service serves mobile customers. Digital cellular technologies provide voice and limited data services. Other wireless mobile telephony services such as narrow and broadband PCS, SMR (iDEN) are late second and early third generation wireless technologies which support many services beyond even enhanced telephony. For this reason, enhanced mobile telephony includes various technologies that support telephone service, enhanced telephone services (such as caller ID, etc.), along with limited data and Internet communications.

Mobile telephony evolved from the early radiotelephone into analog cellular (AMPS). The genesis of the wireless telephony market can be traced to GI's returning from World War II (who were used to military walkie-talkies) and demanded the wireless radiotelephone service of the Armed Forces as they returned to civilian life. Radiotelephone is an imprecise term because many wireless devices can now be used as telephones. Historically, radiotelephones were the technology used by Police vehicles in the 1920's. Shortages of spectrum and cumbersome, expensive equipment with high power consumption were the rule until AT&T (benefiting from its wartime technological breakthroughs) launched mobile radiotelephone service in 1946 [Stone, 1997, p. 144].

Yet, almost forty years later the postwar radiotelephone market was extremely limited. According to *Fortune* magazine,

> At the end of 1983, this service was so limited that even in New York City, only twelve subscribers at once could be engaged in conversation with a total subscribership of 730 and a waiting list of two thousand. [Colin Leinster, *Fortune*, August 6, 1984, p. 108]

Even when a call could be placed, mobile radiophone connections had poor sound, frequent static, interference, and other noise in addition to being extremely expensive and bulky.

Cellular was proposed internally at Bell Labs in 1947, with publication of basic ideas in 1960. Out of this work came AT&T's 1971 proposal for analog cellular service or AMPS

(Advanced Mobile Phone Service). In 1974, the FCC ordered that only wireline telephone companies could be cellular carriers. Because service required blocks of 20 MHz, the 40 MHz cellular radio spectrum allocation could go to a maximum of two companies per CMA (Cellular Market Area) at a maximum. From 1974 to 1979, the FCC adopted a cautious attitude granting construction licenses conservatively. Japan and Sweden moved at a faster rate than the US system whose standards were incompatible with the foreign systems. By 1981, the FCC allowed one wireline ILEC and one non-wireline carrier determined by "competitive" application per market [Stone, 1997, p. 147].

The AT&T breakup led to the issue of whether RBOCs or AT&T got custody of the cellular market. The strict regulatory distinction between local and non-local services meant that, instead of AT&T, only RBOCs (defined as local) were awarded "wireline" cellular franchises. However, RBOC boundaries followed state lines, while cellular service followed the curved contours of radio coverage areas and FCC-defined CMAs. Non-wireline franchises engaged in lengthy rent-seeking lobbying in order to be declared the "competitive" applicant.

McCaw (a Florida company) developed a mobile digital cellular technology separate from AT&T's AMPS. D-AMPS (Digital AMPS) was brought into service in 1992 to relieve existing cellular network congestion. McCaw devised a Cellular One system where national coverage could be handled by one carrier, eliminating expensive roaming charges and differences in service variability and availability. Sweden's Ericsson developed technology to install D-AMPS onto an existing AMPS network, without requiring any additional radio frequencies. McCaw rolled-out the new digital service in south Florida. Digital technologies allowed less distorted calls and value-added services such as paging through the same customer equipment. McCaw also pioneered the CDPD (Cellular Digital Packet Data) system where speech and data compression technologies allowed data packets to be transmitted simultaneously with voice conversations [Stone, 1997]. AT&T ended up purchasing McCaw Cellular in a 1994 deal worth $11.5 billion to create the first nationwide digital cellular carrier.

Nationwide, the 100,000 cellular subscribers in 1984 boomed to 3.5 million by 1989 to reach 5.3 million in 1990 and 23.2 million in 1994. In 1995, the expectation for the year 2000 was 46.9 million cellular customers [Stone, 1997, p. 145]. However, by 1998, over 69 million mobile telephony subscribers produced over $30 billion in service revenues nationwide [FCC 99-136, 1999, p. B-2]. At the end of 1998, 49.2 million subscribers were analog cellular customers. There were some 20 million digital wireless subscribers using four technologies: GSM (2.7 million, all broadband PCS), TDMA (8 million, broadband PCS and digital cellular), CDMA (6.4 million, broadband PCS and digital cellular), and iDEN (2.9 million, digital SMR) [FCC 99-136, 1999, p. B-10]

PCS is an acronym that stands for Personal Communications System. PCS was discussed as a wireless mobile technology in 4.4. However, the PCS market is harder to define than the PCS technology. According to the NTIA, "PCS represents a considerable technological improvement over early analog cellular services, incorporating digital voice compression, complex CDMA or TDMA access protocols, and a fast-growing variety of advanced services." [Vanderau, Matheson, and Haakinson, p. 19, 1998]

Unfortunately, multiple definitions have sprung up for the term PCS. The concept often becomes broad as with attorney Thomas A. Monheim's conceptualization of PCS:

> Imagine having one, permanent telephone number and a small, wireless telephone that you could carry and use everywhere --- at home, at the office, or in the car. Imagine having a laptop computer that had built-in radio functions and was connected to a wireless local network. Imagine having a sensor in your car that was part of an intelligent vehicle highway system that kept you appraised of traffic conditions and ideal commuting routes. These are just a few of the scenarios that may become everyday reality with the development of advanced PCS. [Monheim, 1992, p. 336]

Other authors say PCS is distinct from other services because PCS uses frequency reuse technology in the 1900 MHz frequency bands, offered by FCC "common carriers" with spectrum obtained at FCC auctions. PCS telephones may allow one and two-way paging, messaging, and even Internet access in addition to voice calls. Fax and video delivery are possible, as is some level of location monitoring (911 capability). Harte *et al.* (1997) give three definitions of PCS:

> 1) Any type of wireless technology, 2) A wireless system operating on the North American 1.9 GHz band, in distinction with a system operating on the 800 MHz 'cellular' band, 3) PCS-1900 technology in distinction to other access technologies. [Harte, *et al*, 1997, p. 404]

It may be easier to use Stone's argument urging the use of operational conceptualizations "to which all interested parties subscribe, rather than definitions." [Stone, 1997, p. 154] PCS does not beat cellular's range of about twenty miles (with 1997 technology) from transmitters to base station, operating better in open spaces. PCS operates at higher frequencies, indoors, outdoors, in tunnels, behind mountains, but has a one thousand-foot range from base station to wireless set in 1997 according to Stone [Stone, 1997]. By the year 2000, Lucent Technologies Flexent CDMA technology was able to extend CDMA base station ranges up to 70 miles, while GSM-based systems are able to reach from 20 to 40 miles.

In 1990, the FCC allocated 220 MHz of spectrum in the 1850 to 2200 MHz band to broadband PCS. Additional allocations were made for narrowband PCS in the 900 MHz band [Stone, 1997]. The U.S. government auctioned additional spectra, receiving over $1 billion in a two-stage auction process administered by the FCC. To provide PCS, expensive infrastructure costs in the tens of billions of dollars nationwide are involved, along with environmental and aesthetic issues surrounding tower construction.

PCS technology and standards are quickly developing around TDMA (E-TDMA), CDMA (W-CDMA and CDMA-2000), GSM, and SMR technologies. These four types correspond to the third generation of wireless technologies (see Figure 4-29 in 4.4) and are associated with PCS, but do not define it. Each standard was a *de facto* proprietary standard sponsored by a different group of carrier and manufacturers. For example, W-CDMA (5 MHz channel) is sponsored by GSM operators, while CDMA-2000 (5 MHz channel) is sponsored by

IS-95 operators. The UWC-136 standard (200 kHz or 1.6 MHz channels) is TDMA or E-TDMA based.

Common wireless mobile devices capable of supporting some form of PCS are shown in Table 4-23. Note that in the space of one year, pricing has fallen from one-half to one-tenth of the 1999 levels as carriers vie to capture an installed base, equipment becomes cheaper to make, and infrastructure costs fall.

Table 4-23: Wireless mobile devices.

	Model name & vendor					
	i1000+	Communicator 9000	SCH-3500	Palm VII	R380	pdQ
Vendor	Motorola	Nokia	Samsung	3COM	Ericsson	Qualcomm
Features						
Basic Voice	Y	Y	Y	N	Y	Y
Caller ID	Y	Y	Y	N	Y	Y
E-mail	Y	Y	Y	Y	Y	Y
Fax	Y	Y	Y	N	N	N
Messaging	Y	Y	Y	N	Y	Y
Note Taker	N	Y	Y	Y	Y	N
Organizer	N	Y	Voice only	Y	Y	N
Scheduler	N	Y	N	Y	Y	N
Web Browser	WAP	WAP	WAP	Y	WAP	AP
Service Partners	Nextel	Geoworks Wireless	Several	Bell South	Several	Kyocero Wireless
Technology	iDEN™	GSM	CDMA	Tech. Independent	GSM	CDMA
Prices in 1999	$1,000-1,200	$1,000-1,200	$1,000-$1,200	$800	Expected, $1,000–$1,200	$1,000-$1,200
Prices in 2000	$149-199	$699	$149	$449	Not introduced	$500-800

Adapted from Zaatari, 1999, p. 136, 2000 prices from Alta Vista Shopping & Letstalk.com.

Another technological standard associated with PCS (shown in Table 4-23) market is SMR (Specialized Mobile Radio). SMR devices are unique, because they are both wireless telephones and private radios able to communicate with other radios in an agribusiness over a secure network. When a private firm in Texas called Carterfone sold radios it manufactured that could also be interconnected to the PSTN, AT&T sued to prevent such interconnections. Carterfone prevailed and that was the beginning of SMR service, where each device could communicate with other radios in a business or with any PSTN telephone. Nextel captured all the SMR (Specialized Mobile Radio) frequencies by buying up the so-called dispatch frequencies and then buying 2,500 frequencies from Motorola in a stock swap. Nextel also took over SMR frequencies through acquisitions and bankruptcies of other firms [FCC, 99-136, 1999]. SMR is neither cellular nor PCS, but it is a mobile wireless telephony technology with a market presence in Florida.

Most wireless telephony devices are sold with service plans so that manufacturers recover costs from carriers (who are paid on a recurring basis rather than entirely up front. The third generation mobile devices shown in Table 4-23 also offer features such as e-mail, fax, messaging, and Internet access. While displays are limited to small screens and web-standards such as WAP and AP are limited, text e-mails, market information such as futures quotes, and limited shopping are available to agribusiness users. Additionally, service areas for two-way e-mail and Internet access are sometimes smaller than for telephony.

4.7.6 Paging and Wireless Messaging

Developed in 1949 by Charles Neergard, pagers are small devices that allow one-way communication or limited two-way communication of messages. Pagers have built in address codes (cap codes) that enable them to receive signals from a ground or satellite radio transmitter. A message is received by a particular pager when the pager's specific cap code is received through broadcast of a radio signal.

The pager market has seen six main types of pagers. The first type is the cap code pager (beeper). These units simply beep when the built-in address is picked up by the pager's radio receiver once the pager's number has been dialed by telephone. The recipient would have to know (in advance) who had called and where to return the call, because cap code pagers could not convey that information. Because all they could do was beep, cap code pagers resulted in the term beeper being associated with pagers. Tone voice pagers, the second type, originated in the United States in the 1970's. Tone voice pagers permit the sender to transmit a brief voice message to the pager-receiver. To page someone, a person dials a local, long distance, or toll-free number (using a touch tone telephone) and speaks a short message.

Digital display numeric pagers (the third type) were introduced in the early 1980's and are still the most commonly used type. These units can display numeric messages of up to twenty numerals such as the caller's telephone number. Paging is accomplished by calling the pager telephone number and then keying in DTMF (Touch-Tone) numerals. Simple alphanumeric pagers, the fourth type, allow numeric messages and extremely limited text messages to be shown on the pager's display. By the early 1990's, paging vendors had added features such as voice mail messaging so that numeric and alphanumeric units would signal when a voice message was left in a subscriber's voice mailbox. The subscriber could then dial the paging vendor's service line (or their pager number), enter a security code, and hear a short voice message from the caller.

By the mid-to-late 1990's, demand for more sophisticated pagers and paging services was experienced. The pager market became the "wireless messaging" market to emphasize capabilities of new pagers and the enhanced services. The fifth and sixth kinds of pagers are advanced one-way word message pagers and advanced two-way word message pagers. Advanced one-way word messaging pagers range from units that display a single line of text and store a few hundred characters of messages to units that have a four line display and 30,000-70,000 character memory capacities. Text messages may be sent from e-mail programs and special web pages.

Motorola's PageWriter 2000™ and the Motorola TimePort are examples of advanced two-way pagers, though the word pager has been replaced by "portable message center". The Page Writer 2000 has its own operating system, infrared PC link and PC communication software, QWERTY keyboard, and addresses and telephone number storage. The Page Writer features up to 4.5MB of flash memory and 256kB of RAM. Messages can be sent to other two-way pagers, one-way pagers, e-mail addresses, and fax machines. Messages can be received from other two-way pagers, from e-mail programs, and through special web pages. However, the two-way coverage area within which messages can be sent *and* received is smaller than the one-way area where messages can *only be received*. Add-on packages allow the pager to be used to display pictures, to play games, and to share software files.

Additional features that may be available on one and two-way word message pagers include delivery assurance, information services (such as stock quotes, news, and weather), out-of-range indication, alarms, voice mail through the unit, multiple colors, message waiting indicators, etc. Some paging vendors are working on the ability to send text pages using ordinary touch tone telephone tones or to use speech-to-text conversion technologies to change voice messages into text.

Advanced two-way pagers may be enabled by several technologies including CVP (Cellular Voice Paging), narrowband PCS, and broadband PCS. Two-way voice paging with compression provides non real-time transmission of voice messages. "The difference between a standard wireless telephone and a two-way voice pager is that the voice pager stores messages in its internal memory." [Harte, Prokup, and Levine, 1996, p. 382].

Paging can be customer-owned or carrier-subscriber. Customer-owned paging can cover a building, farm, or entire state. Agribusinesses that operate a private paging system must be FCC licensed to operate as LMRS (Land Mobile Radio Services) operators if coverage exceeds localized on-site or in-building coverage. All types of paging service can be provided in a customer-owned system.

Pricing ranges from month-to-month pager rental and service to the fixed cost of purchasing the pager and a monthly service charge. The size of the service area (local, statewide, regional, or national) and the pager's telephone number (local, FX, or regional or national toll-free) are other factors in pricing. Most alphanumeric pagers are priced on a per month basis, with annual discounts. Depending on the paging company, there is a maximum number of messages available for a monthly charge, with a fee per message if the maximum is exceeded. Advanced two-way pagers require special coverage areas for the two-way feature to work. Most pager coverage areas can be variable in rural areas, depending on terrain, vegetation, and sometimes weather or solar conditions. Some pagers also have sky-to-ground, marine-to-shore, and satellite (international) coverage.

Device-device convergence is blurring the line between wireless messaging, hand-held palm PCs, wearable computers, cellular telephones, and PCS telephones. The new generation of pagers can prove very handy to agribusiness employees who are often away from telephones, etc. While digital telephone prices are dropping, the pricing for advanced portable two-way message centers (pagers) may be more attractive per text bit transmitted. Two-way pager rates are often more attractive because since they are more likely to be fixed recurring monthly charges instead of a combination of recurring charges and usage-based tolls that predominate in the mobile telephony market.

4.8 The Private Data Networking Market

Private data networking has become a hypercommunication sub-market after arising as an offshoot from the circuit-switched voice network (PSTN). In addition to using dedicated point-to-point circuits such as T-1s (4.7.3) and circuit-switched connections such as ISDN (4.7.4), data networking now relies on packet and cell-switched connections and value-added services that go beyond a physical OSI layer connection. This section highlights several services and technologies that are used for private data networking. Many of these technologies can carry all kinds of hypercommunication traffic from computer data to voice, video, fax, and PSTN. The emphasis is on private computer networks, but many of the technologies mentioned here are fully adaptable to converged hypercommunication use.

Figure 4-48 shows how private data networking fits with the material covered thus far and with the Internet (to be covered in the next section). Together, these seemingly separate elements are converging into hypercommunications. The fact that the elements do not fit neatly into any classification should not cause the reader to worry. Instead, it must be realized that the artificial technical and regulatory separations will be swept away with convergence. However, many features of data communications differ from the voice-orientation of POTS and enhanced telephony. Once private data networking is added to the voice perspective (and both are put together with the Internet), the reader should have a good idea of what hypercommunication services and technologies are. Everything inside the dotted line will be covered in 4.8.

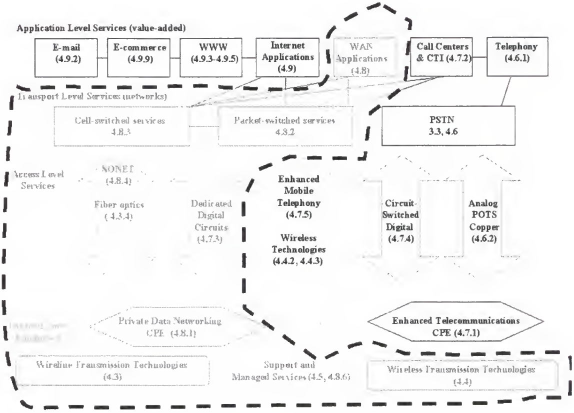
Application Level Services (value-added)
E-mail (4.9.2)
E-commerce (4.9.9)
WWW (4.9.3-4.9.5)
Internet Applications (4.9)
WAN Applications (4.8)
Call Centers & CTI (4.7.2)
Telephony (4.6.1)
Transport Level Services (networks)
Cell-switched services 4.8.3
Packet-switched services 4.8.2
PSTN 3.3, 4.6
Access Level Services
SONET (4.8.4)
Fiber optics (4.3.4)
Dedicated Digital Circuits (4.7.3)
Enhanced Mobile Telephony (4.7.5)
Wireless Technologies (4.4.2, 4.4.3)
Circuit-Switched Digital (4.7.4)
Analog POTS Copper (4.6.2)
Private Data Networking CPE (4.8.1)
Enhanced Telecommunications CPE (4.7.1)
Wireline Transmission Technologies (4.3)
Support and Managed Services (4.5, 4.8.6)
Wireless Transmission Technologies (4.4)

Figure 4-48: Topics in private data networking.

From the private data networking perspective shown in Figure 4-48, there are several levels leading up from the transmission technologies mentioned in 4.3 and 4.4. The first three correspond with the QOS reference levels presented in 4.2.3. First in the physical equipment level (or QOS local level at the agribusiness), connections of CPE to access level services are specialized in data communications, though enhanced telecommunications CPE may still be used also. Second, on the access services level, the only new section (SONET networking) was touched on already in 4.7.3 as a dedicated digital circuit. For this reason, those two arrows are within the dotted line in Figure 4-48, but some circuit-switched connections are used in data networking as well. Wireless technologies and access methods can be useful in private data networking, but since they fit in with the cell-switched, packet-switched, or PSTN categories of transport level services, they get brief coverage in 4.8.5.

The third and fourth levels in Figure 4-48 can be mapped to the OSI reference model with its seven layers of communication between two users of a network. However, application level services rely on every QOS level. Value-added application level services in Figure 4-48 may include the application, presentation, and session layers of OSI, while transport level services tend to include the OSI transport and network layers. Up until now Chapter 4 has focused on physical layer connections and lower data link layer links. The rest of Chapter 4 deals with more complicated networking issues as represented by higher OSI layers. Table 4-24 shows the sub-sections of 4.8.

Table 4-24: Elements of the private data networking market.

Item	Examples	Section
Networking equipment	CPE, DCE, DTE	4.8.1
Packet-switched networks	X.25, frame relay, SMDS	4.8.2
Cell-switched networks	ATM	4.8.3
SONET and fiber optic data networking	SDH, FDDH	4.8.4
Wireless WANs	MMDS, LMDS, WLL, DEMS, 2.4 GHz	4.8.5
Support and managed services	Network management, security, monitoring	4.8.6

Two tasks must be performed to illustrate the foundation of private data networking further before the topics in Table 4-24 can be intelligently presented. First, an evolutionary chain from the circuit-switched and point-to-point dedicated circuits (leased lines) to the internetworked world of packet and cell-switched virtual circuits has to be developed. Second, the relationship between physical layer connections (as discussed in 4.7) and higher layer technologies (covered in 4.8 and during 4.9) must be made apparent through three levels of the OSI reference model. These tasks can be done together by considering interactions among markets, generations, and OSI layers.

The evolutionary chain roughly follows the six generations of computer networking outlined in Figure 3-6, discussed in section 3.5. Three important interactions are at work.

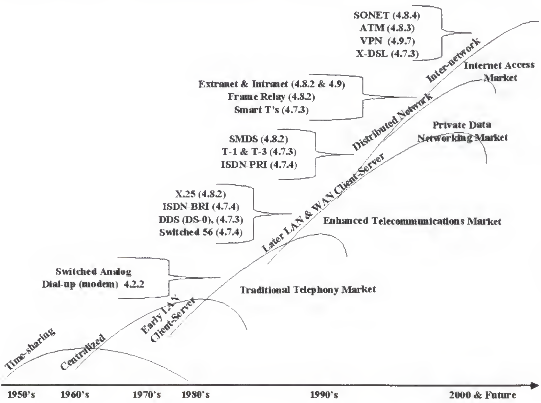

Figure 4-49: Networking generations, associated technologies, and markets.

The first interaction, (shown in Figure 4-49) is among the network generations, their associated technologies, and three markets (advanced telecommunications, private data networking, and the Internet). Data communication needs for the first three generations (time-sharing, centralized, and early LAN peer-to-peer and client-server networks) were mainly provided by switched analog and dial-up modem connections that used the traditional telephony market. By the mid 1980's as peer-peer LANs and client-server LANs began to require part-time circuit-switched connections to remote facilities, switched analog services and dial-up modems were the only technologies required.

Proceeding up the generational life cycle to later WAN & LAN client-server networks, the enhanced telecommunications market provided physical connections such as ISDN-BRI, DDS, and Switched 56 leased lines. Slow, packet-switched technologies such as X.25 (that could work under noisy analog lines) were early private data networking services used at this time. As LANs became more complex and more likely to connect and form WANs, slow-speed digital enhanced telecommunications services such as circuit-switched ISDN-BRI and dedicated DS-0 became popular.

Another packet-switched data networking market offering was SMDS, also accompanied by physical layer T-1, T-3, and ISDN-PRI enhanced telecommunications connections. SMDS was created by the RBOCs to provide packet switched data networking for WANs and early distributed networks. These four technologies are associated with later WANs and early distributed networks. The advent of distributed networks required still more complexity and speed so that fast enhanced telecommunications services such as dedicated T-1s and circuit-switched ISDN-PRI became more popular.

Later distributed data networks became increasingly sophisticated requiring the flexibility offered by enhanced telecommunications smart Ts and new genres of pure data networking packet-switched networks such as frame relay. By the mid 1990's, cheaper value added packet-switched offerings such as frame relay and Intranets began to replace expensive telco leased dedicated lines and point-to-point enhanced technologies.

The internetworking generation has seen the establishment of SONET, ATM, and Internet VPN technologies to take advantage of the lower costs of private cell-switched and public IP-based networks. With the exception of DSL, instead of serving as access methods alone, later private data networking and Internet market technologies were offered with many intermediate OSI layers that go beyond mere connectivity into the realm of value-added services.

The inter-network generation required the introduction of converged networking technologies such as SONET and ATM. The introduction of DSL allowed an inexpensive alternative to expensive dedicated enhanced telecommunication connections to be available. The capstone of the inter-networking generation are VPNs (Virtual Private Networks) that use Internet access and TCP/IP to create private network tunnels over the Internet, covered in more detail in 4.9.7.

It can be especially difficult to separate services from technologies in today's private data networks. Both data and voice travel over WANs, Intranets, and Extranets that use technology combinations such as frame relay over copper, ATM over fiber optics, and T-1 carrier over wireless. The private data networking market relies on physical layer enhanced telecommunications technologies to access a family of value-added services and technologies. Therefore, agribusinesses gain greater hypercommunications flexibility, lower costs, and less responsibility for day-to-day management of data networking.

As each generation progressed, new kinds of connections, DTE, and DCE became needed as data communications spanned ever-larger distances. The separation of data networking from the PSTN-based POTS and enhanced telecommunications was spawned in two ways. First, as local computer networks began to require connection to regional and international networks the new WAN applications needed specialized data switches and other carrier DCE. However, high telco prices for the necessary dedicated and circuit-switched leased lines left many businesses unable to afford enhanced telecommunications solutions to their data communications and networking needs. Second, as computer networks became composed of DTE and DCE from many manufacturers and diverse software platforms, interconnection rather than telco standardization were demanded by the data communications market. The complexities of interconnecting different kinds of business networks were often made worse by the technical requirements telcos placed on enhanced telecommunication leased lines.

The second interaction, between the six economic generations of computer networks and the seven levels of the OSI model underscores the differences between enhanced telecommunications, private data networking, and Internet-based networks. As generations unfold, middle (and upper) level carrier services grow in importance as illustrated by Table 4-25.

Table 4-25: Computer network generations and OSI model.

Generation	Key OSI layers	Example protocols	Physical layer connections
Centralized	1,7	Asynchronous	Modem
Time sharing	1,2,7	Asynchronous file transfer	Modem, Switched 56
Peer-peer LANs	1,2	CSMA	Coax
Client-server LANs	1,2	Ethernet, fast Ethernet, wireless	Cat 3-5 twisted pair
Client-server WANs	2,3	Protocol stacks (Novell, MS networking, SNA, etc.), X.25	Leased lines (dedicated connections, ISDN)
Distributed Networking	2,3,4	Frame relay, SMDS	Network protocols over copper
Inter-networking	3,4,5	TCP/IP, alternatives allow nested TCP/IP, ATM	SONET, fiber optic carriers
Internet networking (VPN)	3,4,5,6	TCP/IP	Variety of Internet access (modem, DSL, leased lines)

While Table 4-25 represents an enormous simplification, some generalizations can be made. First, data networking services and technologies differ from enhanced telecommunications offerings because middle OSI-level functions were not economically and technically necessary until the advent of distributed WANs, inter-networking, and the Internet. Second, faster speeds and better carrier transport meant that as generations progressed, addressing, hierarchical networking levels, and other concerns required middle OSI-level protocols to provide higher levels of service.

A third and final interaction is between the OSI layers and the services themselves. This interaction is more complicated than Figure 4-50 shows, but is at the very core of the reason that enhanced telecommunications services (though they can be used for data networking) were covered in conjunction with voice communication. As Figure 4-49 related the economic generations of computer networks to data networking technologies, so Figure 4-50 relates the economic generations to the technical OSI layers. One way to begin to understand this is by comparing a T-1 point-to-point dedicated connection to ATM or frame relay.

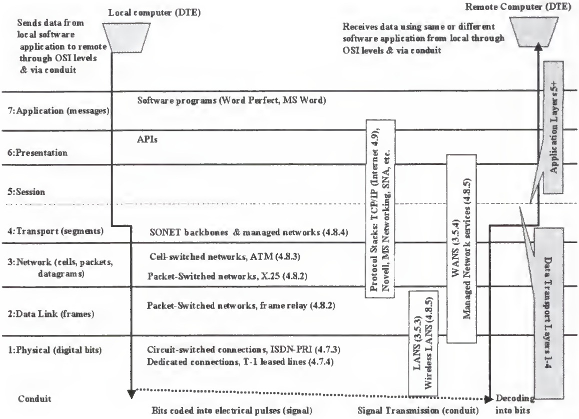
Local computer (DTE)
Sends data from local software application to remote through OSI levels & via conduit
Remote Computer (DTE)
Receives data using same or different software application from local through OSI levels & via conduit
7:Application (messages)
6:Presentation
5:Session
4:Transport (segments)
3:Network (cells, packets, datagrams)
2:Data Link (frames)
1:Physical (digital bits)
Conduit
Software programs (Word Perfect, MS Word)
APIs
SONET backbones & managed networks (4.8.4)
Cell-switched networks, ATM (4.8.3)
Packet-Switched networks, X.25 (4.8.2)
Packet-Switched networks, frame relay (4.8.2)
Circuit-switched connections, ISDN-PRI (4.7.3)
Dedicated connections, T-1 leased lines (4.7.4)
Protocol Stacks: TCP/IP (Internet 4.9), Novell, MS Networking, SNA, etc.
LANS (3.5.3)
Wireless LANS (4.8.5)
WANS (3.5.4)
Managed Network services (4.8.5)
Application Layers 5+
Data Transport Layers 1-4
Bits coded into electrical pulses (signal)
Signal Transmission (conduit)
Decoding into bits

Figure 4-50: Interaction among OSI layers and hypercommunication services.

Figure 4-50 shows the differences in data networking services and technologies within the context of the OSI model. First, notice that the enhanced telecommunication circuits mentioned in 4.7 are shown in the physical layer at the bottom of Figure 4-50 since their role in private data networking is below higher-layer services. At the second OSI layer (the data link layer) packet-switched networking services and technologies such as frame relay are shown.

While packet switching relies on physical layer connections for transmission, higher level services (such as ATM) and protocols for error checking and other purposes have become even more necessary as networks get more complex.

Most recently, the private data networking sub-market has become increasingly based on the Internet. Traditional LANs and WANs still make up the bulk of data networks, but thin clients, Intranets, and Extranets are becoming increasingly popular [Koehler, *et al.*, 1998]. Some such networks are "power" networks that add voice to the equation, as well as facsimile, paging, and secure Internet access through a firewall.

Both Microsoft and the US government (GSA, *FED-STD-1037C*, p. I-15) make a distinction between an internet and the Internet. Small i internet is given the familiar definition of a "network of networks" which includes but is not limited to the Internet (capitalized). An internet, under this view, includes any network of networks ---from two interconnected LANs in a small business to the Pentagon's worldwide WAN or AOL's content network. Networks, covered in detail in Chapter 3, are "a series of points or nodes interconnected by communications paths. Networks can interconnect with other networks and contain subnetworks." [http://www.whatis.com/network.htm, December 1997]

Intranets are corporate networks that use the TCP/IP protocol stack to operate. Extranets are like Intranets in that they have a corporate scope, but Extranets are private TCP/IP networks that connect a firm to suppliers, major customers (such as wholesalers), and to investors and other stakeholders. Such networks (discussed in 4.9) typically have "closed" rather than "open" architectures.

4.8.1 Networking Equipment

At first glance, private networking seems to be an environment occupied by computers, data transmission, and internal e-mails. In fact, by using private networks, far-flung agribusinesses may actually benefit more than their city cousins because of the cost savings and increased communications of seamlessly merging voice, data, and Internet traffic into one unified whole. That whole, in turn, is able to do everything the telephone call and fax of old did for a small fraction of the cost. Additionally data networking applications support new features such as real-time video, voice and video conferencing, GIS monitoring, real-time weather, emergency services, etc.

Every kind of device needed for private data networking cannot possibly be described here. However, Table 4-26 sketches several important examples that are followed up by the examples of Figures 4-51 and 4-52.

Table 4-26: Private data networking equipment.

Technology	Function	OSI layer	Text location
WAN Switches	Switch traffic such as frame relay, X.25, or SMDS in carrier networks.	Network layer	4.8.1
Routers	DCE Devices that connect sub-networks or networks using routing tables.	Data link layer	
Gateways	DCE Devices that connect one network to another using different operating systems or on different platforms.	Multi-layer, typically at application layer	
NIU	Edge devices: connect on-premise conduit to local loop or carrier network.	Physical and data link layer	4.7.2
CSU/DSU			
Special servers	Computers dedicated to specific purposes such as database, etc.	Multi-layer	3.5.3
Wireless WAN CPE	Transceivers and antennas that allow establishment of wireless communication paths.	Physical layer	4.8.5
Firewall	Protects network security.	All layers (software and hardware)	4.8.6, 4.9.8
Thin clients	Specialized workstations for network computing without hard drives or CPU.	User device	4.8, 4.9

The terminology of private data networking equipment is seldom as clear as Table 4-26 suggests since manufacturers, carriers, and network protocols may define the same device using different terms. WAN switches, routers, and gateways are the only entries not covered previously. Routers are used to interconnect similar parts of a network. Routers may be used in LANs, WANs, and always in IP-based networks such as the Internet. Each router routes packets from one location to another using special routing tables that recognize where a packet needs to go based upon specific network addresses expressed in quad notation such as 10.245.15.9[37]. WAN switches can be physical devices or layer 3 switches (software protocols) that offer high-speed routing from one location to another as part of a WAN. Gateways are specialized server-switch combinations that translate data communications between two or more diverse systems.

One way to explore the revolutionary new market in networking services and technologies available to Florida agribusiness is by looking at the State of Florida's private data network. Within this system are found many of the typical problems and opportunities faced by private data networks, along with critical security concerns and life and death reliability requirements for law enforcement, emergency, and medical communication.

Florida's RTS (Router Transport Service) network is a state Division of Communications network that offers multi-protocol, routed data communications. It is the State of Florida's private data network. The Division of Communications contracted with BellSouth, GTE, and Sprint to run the network end-to-end (see support and managed services in 4.8.6). This outsourcing of the management of the WAN frees state agencies to avoid worrying about maintaining the data networking equipment that connects the local network of a particular agency to the statewide WAN that carries traffic for all state agencies.

Figure 4-51 shows the nodes in the state's RTS private data network [State of Florida, 1995]. Each node has a collection of sub-networks that serve a specific geographic area. Node locations have been chosen because of their definition as LATA nodes in the PSTN.

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[37] More explanation of network addressing is found in 4.9.3 when IP addresses are discussed.

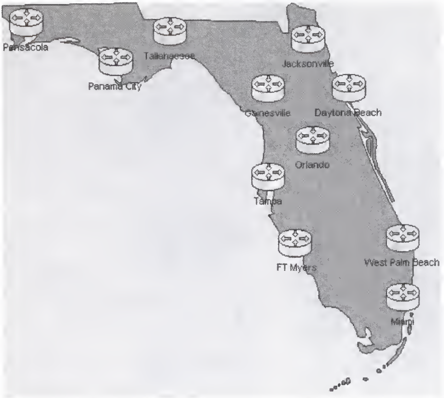

Figure 4-51: Nodes in Florida state government's private data network.

It might seem as though the state's enormous network would not be an example that would aid in understanding private data networks for agribusinesses. However, now, even small companies can benefit from the savings and network designs once only affordable for an enormous organization such as the State of Florida. Before the 1986 Florida High Technology and Industry Council report [FHTIC, 1986], state agencies relied on un-integrated data and voice networks. By the early to mid 1990's, migration into an integrated data network was progressing, but voice transport lagged behind. Certainly, the state has the need for a more complex network than any single agribusiness, but one cornerstone of technological changes in hypercommunications is that they are scalable. Small organizations end up being able to afford solutions previously available to large organizations as technology changes rapidly.

Details of the Pensacola node of the state's RTS WAN show routers, hubs, and frame relay devices that might be typical data networking equipment in a business network. Several features are noteworthy about the Pensacola example as shown in Figure 4-52 [State of Florida, 1995]. First, the Pensacola hub has a dedicated point-to-point connection with Tallahassee (the headquarters location). The Pensacola CPE would include a DSU/CSU as an edge device for the T-1 (dedicated leased circuit) to Tallahassee. Some traffic from connections to the Pensacola hub to destinations outside of Pensacola would travel through that T-1 to Tallahassee and (if continuing beyond Tallahassee) to other points as shown in Figure 4-52.

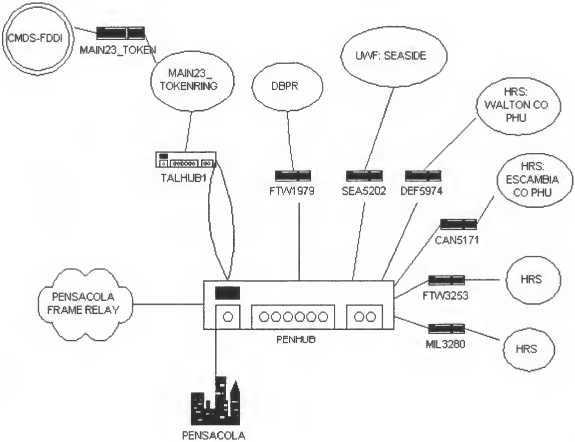

Figure 4-52: Detail of Pensacola node CPE DCE.

However, frame relay traffic would go to the Pensacola frame relay cloud on the left of Figure 4-52 and then be switched at a higher OSI layer to destinations elsewhere in the state. The Pensacola hub is not only a node on the state WAN, it is a gateway, a WAN switch, and the hub of a MAN (Metropolitan Area Network) serving users in and near Pensacola.

Traffic within the Pensacola area is handled by routers such as DEF5974 which is the edge device for a circuit that goes to the Walton County HRS office. That connection is also a dedicated connection, in this case a 64 kbps DDS circuit. Other routers are local to the state office where the Pensacola hub is located and simply switch LAN traffic from one part of the building to another.

The difference between the T-1 and DDS dedicated connections (which require leasing of expensive point-to-point links between Pensacola and other locations) and the frame relay connection (which uses virtual circuits) is important to understanding private data networking. The point-to-point connections rely on simple physical layer connections, while frame relay is an example of a data link layer networking protocol.

Data link protocols provide four essential services (framing, error detection, retransmission, and media access) for private data networks. Table 4-27 summarizes several current and historical data link protocols that control physical layer data communications.

Most of the private data networking technologies and services to be covered are based on these variations. In the second column, next to the name of each protocol is the size of the packet, frame, or cell that data is transmitted in. The next column mentions the error detection scheme, with CRC (Cyclic Redundancy Checksum). The retransmission mechanism shown in the next column refers to how the network controls the information flow so that the buffer of the receiving device does not overflow [Sheldon, 1999]

Media access (also known as Medium Access Control) are rules that govern when devices that share a resource can transmit so as to avoid collisions (interruptions) that would interfere with communication. Note that the last three types are all routed which is the hallmark of modern data networking. Finally, efficiency refers to the percent of each transmission that is available for user information instead of network headers that act as envelopes or addresses.

Table 4-27: Efficiency of asynchronous and synchronous data link layer networking protocols.

Protocol	Packet, frame, or cell size (bytes)	Error Detection	Retransmission (flow control)	Media Access (MAC)	Efficiency	Max. Data Rate
Asynchronous	1	Parity	Continuous	Continuous	70.0%	56 kbps
Asynchronous File Transfer						
Xmodem-CRC	132	8-bit CRC	Stop & Wait	Point-to-point, controlled	97.0%	56 kbps
Ymodem	1029	16-bit CRC	Stop & Wait	Controlled	99.5%	56 kbps
Kermit	1000	24-bit CRC	Continuous	Controlled	99.4%	56 kbps
Synchronous						
SLIP	varies	none	none	Full duplex	99.8%	56 kbps
PPP	<1508	16-bit CRC	Continuous	Full duplex	99.5%	1.5 Mbps
Token Ring	varies	32-bit CRC	Stop & Wait	Token Ring	99.6%	100 Mbps
Ethernet	<1518	32-bit CRC	Stop & Wait	CSMA/CD	98.3%	1 Gbps
ATM	53	end-to-end	Continuous	Routed	90.6%	10 Gbps
X.25/ LAP/B	128	16-bit CRC	Continuous	Routed	99.2%	2 Mbps
Frame Relay	varies	16-bit CRC	Continuous	Routed	99.2%	45 Mbps

Source: FitzGerald and Dennis, 1999.

As the rest of 4.8 will show, as networks increase in complexity network layer protocols and services are needed to encapsulate frames into packets or cells. Packets and cells are routed to addresses that may be several layers removed from a simple LAN or a simple physical layer point-to-point connection. These differences are why private data networking and enhanced telecommunications have become two different markets.

4.8.2 Packet-Switched Services

Packet switching differs from circuit switching because instead of a switched dedicated open circuit from one point to another communication is digitized and divided into discrete chunks called packets. With circuit switching, a particular data file, voice conversation, or other message travels as a unit over a precise route in a network. However, with packet switching, messages are divided into multiple packets. The entire network is less expensive to operate and has more route flexibility since individual packets need not travel the same exact route from sender to receiver, nor are packets necessarily received sequentially. Hence, packet switching requires that the message be reassembled in order at the receiving end before it reaches the destination DTE.

There are enormous advantages in network efficiency for packet-switched networks compared to circuit-switched networks. All three core network engineering problems (combinatorial, probabilistic, and variational) can be more efficiently solved in packet-switched networks than in circuit-switched networks. Under circuit switching, once a circuit is in use, the circuit is reserved by the two computers or telephones involved. Under packet switching, a greater volume of traffic may be packet into shared virtual circuits.

In a congested network, some packets may arrive late or fail to arrive at all. Each packet switched networking technology handles late or missing packets differently. The size of a packet varies from a few bytes to over 1000. Each packet carries address information in its header, which acts like a postal envelope for carrying information. The proportion of each packet taken up by the header is called overhead.

The Internet is a packet-switched network, but details of the Internet are found in 4.9 because the subject now concentrates on the building blocks of packet-switched private data networks. Table 4-28 shows several examples of other packet-switched network services and technologies. Packet-switched networks require a carrier technology on the physical layer to carry packets since they are not physical connections per se. Hence, packet-switched network services and technologies sit on top of dedicated circuits such as T-1 carriers between the demarcation point at the agribusiness and the service provider's POP. After that point, packets are split up to travel over the frame relay cloud (or other packet network) until they emerge from the distant POP to travel over the remote local loop to reach the destination.

Packet-switched networks come are based on a variety of service primitives (mentioned in 3.4.2). For example, packet-switched services may be based on connectionless datagram or connection-oriented virtual circuits. Connection-oriented service primitives require connection establishment delay to set up the virtual circuit while there is no establishment delay for connectionless services. Each service is classified as reliable or unreliable based on whether the service itself performs error checking or allows a higher OSI layer to perform that function. Reliability in this sense is different from QOS reliability.

Table 4-28: Packet-switched private data network services.

Item	Function	Carrier technologies	Data rate
X.25	Packet-switched virtual WAN	analog lines	64 kbps to 2 Mbps
Frame relay	Fast packet-switched virtual WAN to replace expensive physical leased lines.	Fractional T-1, T-1, T-3	56 or 64 kbps to 1.544-45 Mbps
SMDS	LAN interconnection.	Flexible, based on ATM technology. Compatible with frame relay, SONET.	56 kbps to 44.736 Mbps
VPN and cyber commuter services (see 4.9.7)	Uses the Internet as a private network using tunneling technologies and encryption	Flexible, any wireline or wireless carrier technology can theoretically support VPN.	From 33 kbps to 45 Mbps

X.25 is a *de jure* CCITT protocol that lets computers on different networks communicate through intermediate DCE over the OSI network layer. X.25 was designed to operate above the OSI data link and physical layers and is especially useful over noisy analog copper lines. X.25 is an older, but still popular service, that uses a reliable service primitive since it provides error checking at every hop end-to-end [Tower, 1999]. X.25 is often criticized because it has high propagation delay, poor interactive capabilities, slow LAN file transfer, and difficult implementation [CyberGate, 1999]

Frame relay (called a fast packet technology since it offers substantially higher data rates than X.25) operates at the data link layer of the OSI reference model. Frame relay can be considered both a service and a technology. As a technology, frame relay originated from X.25 and ISDN standards. Frame relay is "at its core . . . a simple Layer 2 protocol." [Wavetek, Wandel, Goltermann, 1999] However, as a more complicated service, frame relay can be a layer two point-to-point connection using a level two link layer protocol that is similar to the ISDN D channel's protocol. Like X.25, frame relay also operates with layer three protocols (such as TCP/IP) where network calls are packet-switched over many links of a network. Since frame relay relies on variable-length packets, it is more suited to data and image traffic.

Frame relay is a private networking technology since even though information is sent via a frame relay common carrier (ALEC, IXC, etc.), an agribusiness' frame relay circuits are themselves shared only among facilities belonging to the agribusiness. Frames leave the agribusiness premises and travel over the local copper loop from the edge device (such as a CSU/DSU) to the carrier's access device at the POP. From the FRAD at the POP, multiple paths may be taken over the carrier's transport network to the destination. Together, these multiple paths make up what is often called the frame relay cloud.

Two kinds of circuits are used in frame relay, the PVC (Permanent Virtual Circuit) and the SVC (Switched Virtual Circuit). A PVC is created by the hypercommunication carrier and has the appearance of an always-on dedicated connection. A SVC is a temporary connection set up by a user as necessary. PVCs are logical connections that can share a single physical connection. Hence, an agribusiness can have many PVCs sharing one physical layer carrier. For example, six T-1 connections from HQ to six branch offices can be replaced by thirty-six inter office PVCs (or more) using the same wires as the T-1s, but at costs of as much as 60% less.

Frame relay circuits are defined and priced in several ways depending on how service configuration parameters are defined and enforced. Five parameters may be used. The first of these is CIR (Committed Information Rate). The CIR (expressed in bps) is the average throughput rate guaranteed by the carrier per PVC. Typically, CIR equals the bit rate (operational speed of the frame relay CPE edge device) multiplied by the average rate of usage in percent

[ACC Corporation, 1998]. There is also a committed burst (B_c) and an excess burst (B_e) for frame relay circuits. The B_c is the maximum number of bits (*not* rate in bps) that a user can place on the circuit during a particular time period, T_c. The B_e is the amount of data put on the network that will be transmitted if capacity is available. Availability depends on how many other PVCs are transmitting and the relationship between CIR and the physical link speed or access rate.

Figure 4-53 shows how these measures are associated. Pricing depends on the ratio of the CIR to the access rate and B_c, B_e, and T_c. The diagonal line shows the rate at which bits enter (are transmitted into the circuit). In the example, bits are entering the circuit at 40 kbps, B_c is 16 kbits, B_e is 16 kbits, and T_c is 16kb/8kbps or 2 seconds. Once agribusiness CPE (such as a DSU/CSU) begins to send more than 16 kbps onto the line (even though the CIR is 8 kbps), there is a risk that data may be discarded before it reaches the FRAD (Frame Relay Access Device) at the carrier's POP. Once the outgoing rate exceeds 32 kbps, the carrier is likely to discard excess data.

Carriers discard policies vary. Some rigidly enforce DE rules, but often agribusinesses will be able to operate at or above the access rate regularly. If packets are discarded, frame relay itself does not notify sender or receiver that happened. Instead, upper layer protocols such as TCP/IP will be able to replace missing frames.

Some service providers may offer 0 CIR on a 1.544 Mbps (T-1 access rate) circuit. Unless the agribusiness understands the other configuration parameters, it might be tempted to think it is getting a dedicated frame relay T-1. A better description of frame relay might be "B_c bits within T_c seconds not exceeding a limit of B_e bits of burst above B_c within T_c." [Wavetek, Wandel, Goltermann, 1999, p.5] While CIR and the access rate are used most often in discussing pricing, the carrier's discard policy and the other parameters may be more important to actual data rates.

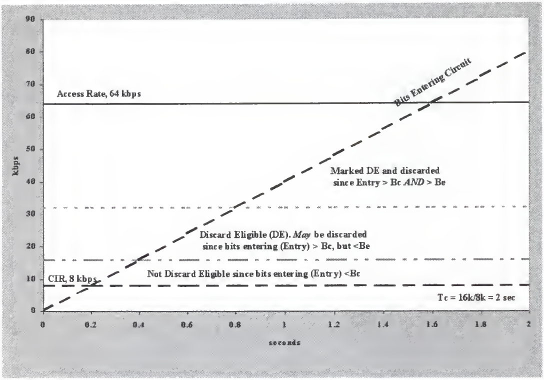

Figure 4-53: Frame relay QOS parameters.

Frame relay offers superior performance to X.25 with lower propagation delay, removal of node-to-node error correction, suitability for interactive use, superior LAN file transfer capabilities, and ease of implementation [CyberGate, 1999]. Frame relay is a popular replacement for point-to-point dedicated circuits because instead of requiring separate physical connections among all WAN nodes, a single physical connection to the frame relay cloud is needed. The result is dramatic savings, estimated at from "40% to 60% over comparable leased line services . . . along with lower costs of equipment and local access." [Paradyne, 1999, p. 3]

Klessig and Tesick (1995) define SMDS (Switched Multi-megabit Data Service) by the terms in the acronym:

> Switched: SMDS provides the capabilities for communications between (any) subscribers just like the telephone network. In fact, SMDS even uses telephone

> numbers to identify subscribers (or at least their data communications equipment).
>
> Multi-megabit: SMDS is intended for the interconnection of LANs and therefore provides bandwidth similar to LANs. The multi-megabit nature of SMDS makes it the first broadband (greater than 2.048 Mbps) public carrier service to be deployed.
>
> Data: SMDS is intended for carrying traffic found on today's LANs. This is generally called data but in fact includes other types of traffic, e.g. images. . . .
>
> Service: When it comes to public carrier data services, there is much confusion between technology and service. SMDS is a service. It is not a technology or a protocol. It will follow the time-honored tradition of public carrier services; the features will stay constant while the technology used in the carrier network is repeatedly improved. For example, SMDS is the first switched service based on ATM technology. [Klessig and Tesick, 1995, p.1]

SMDS is an unreliable datagram service since it does not check for errors at each node in the data link layer as X.25 does, instead relying on higher level protocols for end-to-end error checking [Tower, 1999]. SMDS is a flexible service since it is compatible with many networking technologies including Novell, Microsoft networking products, and TCP/IP. Furthermore, varieties of DCE are compatible with SMDS such as DSU/CSUs, routers, bridges, and gateways. Frame relay and ATM technologies can be used in conjunction with SMDS.

Since SMDS is deployed primarily by RBOCs, it is an expensive service that is not as popular with businesses as frame relay is and ATM is expected to become. However, unlike frame relay, SMDS speeds are guaranteed at the full purchased rate, reliability is likely to be superior over well-engineered networks, and there are no discarded packets. However, the availability of SMDS is limited [Intermedia, 1999]

4.8.3 Cell-Switched Networks: ATM Technology

ATM stands for Asynchronous Transfer Mode, a fast packet cell-switching technology that can handle both voice and data. ATM is called asynchronous because "information streams can be sent independently without a common clock [Saunders, 1996, p. 161]. ATM uses PVCs and has other characteristics of packet switching but ATM's delay characteristics are more like circuit switching [Kumar, 1995]. For that reason, ATM is seen as the network technology that will enable hypercommunications convergence [Adams, 1997]

Cell-switching is similar to packet switching in that packets are used, but ATM uses fixed packets that are 53 bytes in length (cells). ATM has no data link layer error checking, instead using TCP/IP or other network layer protocols to error proof transmissions.

ATM is used to support the transport level for many telephone and data carrier backbones. ATM is also used over dedicated T-1, T-3, and SONET private data networking circuits. While ATM can be used for LANs, its main use is for WANs and even larger backbone networks. Data rates range from 45-52 Mbps to 155 Mbps using SONET or T-3 carriers as physical layers [FitzGerald and Dennis, 1999]. The higher speeds are a result of the small packets (cells), absence of layer two error checking, and ATM's use of fiber optic cables for the physical layer.

Figure 4-54 [Florida Department of Management Services, 1995] shows a large-scale ATM network, the SUNCOM network operated by the State of Florida. The SUNCOM network is used to support a variety of voice and private data networking services. The evolution of SUNCOM is discussed by the State of Florida Department of Management Services in 1995:

> The SUNCOM network has evolved over the years from a pool of intrastate WATS lines for voice communications into a truly integrated modern digital network capable of supporting: dedicated services such as agency specific networks; switched voice and data service for instate and nationwide communications; video teleconferencing services for hearings, meetings, and instructional purposes; dedicated radio control circuits for control of remote base stations and transmissions; and data communications enhancements such as SNA transport, protocol conversion, frame relay transport, and router transport services. [Florida Department of Management Services, 1995, p.106]

The regional hubs shown in Figure 4-54 are often connected to a ring or other network design in the immediate area of Pensacola, Panama City, Tallahassee, Jacksonville, Gainesville, Daytona Beach, Orlando, Tampa, and Fort Myers, West Palm Beach, and Miami. Because this network was born in monopoly days, sprang up under heavy regulation, developed during pre-deregulation, and grew exponentially during de-regulation, some hubs such as Panama City and Daytona Beach might be artifacts of regulation due to LATA boundaries.

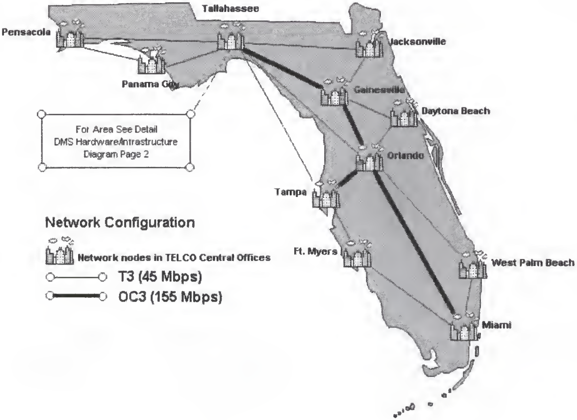

Figure 4-54: Florida state government's SUNCOM ATM network backbone.

Even by 1995, (quite early in the development of ATM as a private data network), SUNCOM was becoming a converged network. The Department of Management Services describes SUNCOM in 1995:

> The State of Florida SUNCOM Network is primarily an intra-state network comprised of eleven state-of-the-art-digital-switches, interconnected by fiber optic cables providing digital transmission trunking at rates up to 45 Mbps. SUNCOM is the government information highway in Florida. The network provides switched services for long distance voice and data, intercity dedicated circuitry, digital cross-connect services for integrating communications services onto the digital backbone, and nationwide switched network services using interstate access from each of the eleven switches. [Florida Department of Management Services, 1995, p. 95]

SUNCOM also encapsulates packet switching, video conferencing, and other hypercommunication services and technologies.

The ATM switch is the building block of an ATM network. All devices must connect to the ATM switch, but ATM switches can themselves be interconnected. Unlike packet switching, cell switching does not have to occur on packet boundaries so that ATM technology can easily handle a mix of real-time voice and video traffic along with less time sensitive data traffic.

ATM allows many hierarchies of service so that traffic can be segregated according to urgency and route, and can be priced accordingly automatically. Typically, packet-switched networks have been most useful for bursty traffic because by using statistical multiplexing on a packet-switched network the number of users served can be maximized for a fixed capacity. Circuit-switched networks have been prescribed as necessary for time sensitive traffic. ATM seamlessly handles both types of traffic making it one of the core technologies of convergence [Alley, Kim, and Atkinson, 1997]

ATM can be used to form a WAN backbone or it can be used for LAN connectivity as well. It is less cost effective as a LAN solution, because as Minoli mentions, "The economics of ATM have to be bifurcated at the LAN and WAN level, because they are different." [Minoli, 1997, p. 9]

ATM requires a variety of specialized equipment depending on the implementation (WAN, LAN, or both) that is in addition to the monthly cost of service charged by the carrier. The required CPE includes NICs, router boards, and DSUs. Together, these comprise ATM access equipment. ATM switch equipment such as private ATM switches, floor hubs (for ATM LANs), and carrier switching equipment must be deployed. ATM may also require specialized fiber optic transmission equipment including premises wiring or fiber, local loop fiber including SONET rings. Also required may be ATM internetworking equipment, video and multimedia equipment, and testing and network management systems and equipment [Minoli, 1997]

Two particular ATM cell formats are important. One is called UNI (User Network Interface). UNI carries information between the user and the ATM network. A second format is known as NNI (Network-Network Interface) which transports information among ATM switches. The UNI style connection could be used by an agribusiness on the access level, while the NNI format is used by carriers on the transport level of a network.

The main reasons for migrating to ATM for WANs include four needs: "more aggregate bandwidth, on-demand bandwidth, efficient use of (expensive) resources," and a "single network management system." [Kumar, 1995, p. 324]. Therefore, ATM QOS is easily monitored and controlled. Hierarchical service levels can be deployed quite easily using ATM with pricing able to change dynamically. ATM may become increasingly affordable for smaller firms and be able to carry the same mixture of voice and data traffic over the local loop that it does over the transport level for carriers.

4.8.4 SONET and Fiber Optic Networking Technology

SONET (pronounced sonnet) is hard to classify. Readers will notice that SONET has been mentioned throughout Chapter 4 beginning with Figure 4-22 where the high data rates it supports dwarfed those of all other transmission technologies, both wireline and wireless. Later, SONET was mentioned concerning fiber optic conduit in 4.3.1. It is important to note that SONET is not necessary to use fiber optic conduit at the local, access, or transport levels of the QOS reference model.

In 4.3.4 SONET was held out as an important example of a fiber optic backbone technology sold as a service to voice and data network providers. In section 4.7.3 (dedicated circuits), SONET's unique route diversity (due to the self-healing ring concept) was mentioned as the reason that communications would not suffer interruption if a fiber optic cable cut occurs. Now, SONET appears as a topic again. This time the discussion centers on SONET private data networking. Since SONET also was mentioned as a carrier technology for ATM in the last section, readers may be confused about the role SONET plays in agribusiness hypercommunications.

The answer is that SONET may play an increasingly important role in agribusiness hypercommunications. Indeed, it is already used by carriers for voice, data, and Internet transport. In the QOS reference model, SONET is both an access level and transport level technology. In the OSI model, SONET can operate from the physical layer up into the transport and session layers. These different functions (and the definition as a connection, technology, and service) are the source of the confusion. SONET may be sold as a glorified physical connection, in conjunction with ATM, as a WAN networking "value-added solution", or as an access and local level solution through which voice, data, and Internet convergence will be achieved.

Table 4-29 shows the SDHs or (Synchronous Digital Hierarchies) that are used to classify data rates of connections in much the way that T-carrier classifications are. Unlike T-carriers (which are defined differently in Europe and Japan than they are in the U.S.), SONET is an international system, making it easier for international traffic exchanges to be made. Indeed Sheldon encourages readers to "think of SONET as a means to deploy a physical network for a global communications system in much the same way that Ethernet . . . (is) used to deploy a LAN" [Sheldon, 1999, p. 903]

Table 4-29: OC (Optical Carrier) SDH (Synchronous Digital Hierarchies).

Circuit	Data rate	Digital telephone lines (64 kbps)	T-1 carriers	Uses (early 2000)
OC-1	51.84 Mbps	672	28	Entry-level SONET. Large WAN or ISP backbone.
OC-3	155.52 Mbps	2,016	84	AT&T Inter-LATA Florida backbone, NSP backbone.
OC-12	622.08 Mbps	8,064	336	Coast-coast NSP backbone.
OC-24	1.244 Gbps	12,096	672	Carrier backbones.
OC-48	2.488 Gbps	32,256	1,344	AT&T national backbone, NSO coast-coast backbone
OC-192	9.965 Gbps	129,024	5,376	AT&T future national backbone, Shared NSP coast-to-coast link.
OC-256	13.271 Gbps	172,032	7,168	Future carrier capacity.

Typically, traffic is mixed within a SONET network. Therefore, while the OC-1 circuit has more capacity than 28 T-1s (43-45 Mbps), overhead and other traffic combinations contain more than a T-3 worth of DS-1 (T-1) traffic. From the table, it is clear that only the largest international agribusinesses are likely to use SONET, whether for a local connection or for an international network.

Although the speeds listed in Table 4-29 are for large-scale businesses, SONET is important even to much smaller agribusinesses for several reasons. First, agribusinesses need to know if their hypercommunication carrier uses SONET and, if so, to what level. This is important mainly for QOS reasons because SONET provides redundancy if service is disrupted at the transport level. Second, the backbone network can help an agribusiness understand why prices for what appears to be the same connection differ so greatly. AT&T's Florida backbone has enormous capacity when compared to the local ISP's T-1 line. That can be important if the agribusiness wants to reduce the chances of a service interruption or trust its traffic to a carrier that can afford not to overbook circuits.

SONET is important to agribusinesses for a third and final reason, the future. As recently as 1995, the backbone capacity of the entire Internet was a T-3 and SONET was unheard of. Now, OC-192 connectivity is shared by Internet carriers between the U.S. east and west coasts, and AT&T expects to have a national converged backbone that large by year's end. Less than ten years ago, an office with thirty employees might have only needed ten analog telephone lines. Firms of that size would never have been able to afford the astronomical prices of a T-1 or needed so much capacity. Now, with fax machines, enhanced telecommunications PBXs, computer networking, e-mail, office Internet use, and the need to host the firm's website, many firms that size would easily be large enough to require at least one T-1. Even if it increased its communications capacity to a size not imagined a decade ago, the same firm would probably spend a lower percentage of total expenses on communications.

Thus, as costs fall and communications needs rise, SONET may become a way to combine voice, data networking, Internet, and business web site traffic onto a single connection. With new services and a combined connection, the monthly bill for one vendor is smaller than the combined total from four separate bills in spite of more communications capacity and use. However, competing technologies such as DSL and fixed wireless may be able to handle the data rate of an OC-1 connection at less than one-fourth the price.

SONET is not the only all-fiber network that agribusinesses can use at the access level. All-fiber PON (Packet Over Network) or POS (Packet Over SONET) technologies may offer wireline fiber connectivity without agribusinesses having to pay the prices carriers expect to charge for currently envisioned value-added SONET networking. POS systems can obtain 25% better efficiency and use IP rather than ATM or other networking protocols. Whether SONET is used as a connection only, used with ATM as a converged services transport carrier, or sold as a value-added local access and WAN solution depends on how PON/POS end up being marketed to businesses.

Two other factors will limit or encourage SONET use by agribusinesses: first, whether the fiber infrastructure is in place, especially in rural areas; second, whether competing technologies (such as wireless) will provide cheaper solutions.

4.8.5 Wireless WANs

The subject of private data networking is not complete without mentioning the category's fastest growing segment, fixed wireless networking. While fixed wireless technologies were discussed in 4.4.2, the topic of wireless WANs is revisited here to remind readers that private data networks can use airwaves instead of copper, coax, or fiber to access provider POPs. In 4.4, a full discussion was made of wireless transmission technologies, from an overview of electromagnetic spectra (4.4.1) to a discussion of the chief terrestrial (4.4.2) and satellite (4.4.3) wireless technologies.

The growth of wireless WANs comes from an explosion in digital microwave that occurred before 1983. Between 1975 and 1980, US terrestrial microwave-installed mileage tripled from 165,000 to 500,000 [Stone, 1997]. Large private companies established point-to-point microwave data links, while new long distance carriers such as MCI and Sprint bypassed AT&T wireline links, using microwave for transport level paths.

However, the importance of wireless WANs for agribusinesses lies chiefly in their ability to bypass the wireline local loop from the agribusiness premises to the carrier POP. Even for agribusinesses that are located in areas where high-speed wireline connections are readily obtainable, wireless WAN providers are able to offer competitive rates for point-to-point connections. Indeed, so far, urban Florida is more likely to see the most promising fixed wireless technologies such as DEMS, LMDS, and WLL as described in Table 4-11 in 4.4.2

There are several other advantages of wireless WANs. Even fixed wireless WANs have a degree of mobility that wireline WANs do not because bandwidth upgrades or changes to the network do not require the lengthy installation and circuit engineering that wireline connections do. Typically, wireless WANs offer lower recurring charges than most wireline alternatives, though initial costs for specialized CPE may be higher. Wireless WANs tend to be more scalable and flexible when the agribusiness requires changes. Some organizations find that wireless WANs make sense as redundant solutions for existing wireline connections to be used during downtime or during periods that have unexpectedly high bandwidth requirements.

4.8.6 Support and Managed Services

Support and managed services for private data networking includes everything from completely outsourcing the operation and maintenance of a firm's data network to one-time network design consulting. Perhaps the most important support service a carrier, software vendor, or hardware maker can provide is technical support. Technical support for a private data network may include the ability to call, e-mail, and chat with support personnel twenty-four hours per day, seven days a week. Support may also allow customers access to diagnostic tools so they can assess whether problems are on the carrier end or at the agribusiness' premises.

Service providers offer many so-called value-added services so that agribusinesses can concentrate on business rather than on data networking. Managed services include basic network monitoring, end-to-end network management, recovery, security, as well as the purchase and installation of CPE.

Basic network monitoring is a service designed for agribusinesses that are able to watch over their networks with their own IT staff but require prompt notification from the carrier of potential physical layer CPE problems. Higher levels of network monitoring are also available, though typically these simply make it easier for agribusiness personnel to respond to, diagnose, and repair network problems themselves. Typically, network monitoring is offered to businesses with CPE that is compatible with the monitoring methodology.

Network management, the next category of managed services, includes proactive end-to-end service provider management of all CPE and carrier network devices for the agribusiness' private data network. Full end-to-end network management solutions are designed for firms with little or no internal staff to manage WAN connectivity. Customers receive detailed monthly reports showing the success rate of outsourced network efforts and usage statistics. Also included may be free equipment repair and replacement, fault isolation, and traffic analysis.

The ultimate form of end-to-end network management includes the services of an application service provider. This service frees the agribusiness of configuring e-mail, database, Internet software, and other software on their own computers. Instead, application service providers host all applications and data at their locations and the agribusiness requires only thin clients as CPE DTE instead of a complicated local network.

Recovery services include automatic backup of network data so that if there is a system crash, data can be restored avoiding the loss of critical data. Security services use outside vendors to monitor the network security, construct firewalls, and provide security recommendations so that the privacy of a firm's data networking is not compromised. Often, redundant circuits are provided to avoid downtime from system crashes, cable cuts, and the like.

The final aspect of support and managed services concerns the purchase, installation of CPE and DTE. While it is certainly possible to save money by purchasing edge devices and other necessary equipment from vendors other than the carrier, there can be several advantages in buying DCE from the communication service provider. For one thing, purchasing CPE directly from the carrier can help avoid the inevitable finger pointing that can result if the data network performs poorly or not at all. Carriers may frequently blame problems (rightly or wrongly) on equipment incompatibilities located on the agribusiness side of the demarcation point. In many cases, carriers may offer special pricing on recurring charges for customers who purchase equipment and installation services. Additionally, pricing for end-to-end network management for a network based on equipment bought from the carrier may be favorable. End-to-end management may not even be available in some cases unless DCE is bought or leased from the carrier.

4.9 Internet Service and Access Market

Of all hypercommunication sub-markets, the Internet may be the most important. One reason is Bill Gates' point that "Already the Internet's pricing model has changed the notion that communication has to be paid for by time and distance." [Gates, 1995, p.97] Another reason for the importance of the Internet is seen through David Crawford's realization that "Internet services are markets for two separate goods, bandwidth and information. The combination of the two is the market for communication." [Crawford, 1997, p. 379]

The Internet is a relatively recent phenomenon as a commercial communications medium. In 1993, Marc Andreessen and others at the University of Illinois developed the first web browser, Mosaic, making use of the IETF HTTP protocol and the HTML protocol. By 1994, Andreessen had founded Netscape. In 1995, Microsoft began its substantial involvement with the

Internet. Internet-related business revenues have grown dramatically with US e-commerce totaling $127 billion in 1999, up from $51 billion in 1998. By the end of 2000, more than $284 billion in e-commerce transactions are expected to occur in the U.S. alone [Nua, 1999]

Figure 4-55 illustrates the exponential growth of Internet hosts, most of them business domains. According to the Internet Software Consortium, in January 2000, the world had 72.4 million hosts. Of those, 24.8 million were .com, 16.8 million .net, 6.1 million .edu, 1.8 million .mil, 1.0 million .org, and 0.8 million were gov [ISC, 2000]. The Internet has become truly an international medium with almost every country in the world having registered domain names, and only a few sub-Saharan African nations and North Korea without any Internet service at all.

The total worldwide Internet audience is difficult to estimate. One 1999 estimate pegged the number of worldwide users at 200 million people, 80 million of whom were US users [Tower, 1999, Ch.2, Part 2, p.7]. In June 2000, worldwide Internet users were estimated at 332 million, of whom 147 million were in the US and Canada and 92 million in Europe. There are 75 million Asia-Pacific users and 13 million users in Latin America [Nua, 2000].

The Internet is often called simply a "network of networks", but as was mentioned in 4.8 the definition requires more precision. More specifically, the Internet is a wide-area, packet-switched network with an open architecture that uses TCP/IP. In more detail, here is IBM's definition of the Internet in 1998:

> The Internet, sometimes called simply 'the Net', is a worldwide system of computer networks - a network of networks in which users at any one computer can, if they have permission, get information from any other computer (and sometimes talk directly to users at other computers). It was conceived by the Advanced Research Projects Agency (ARPA) of the U.S. government in 1969 and was first known as the ARPAnet. . . . because messages could be routed or rerouted in more than one direction, the network could continue to function even if parts of it were destroyed in the event of a military attack or other disaster. [www.whatis.com/internet.htm, p.1, last updated 10/13/98]

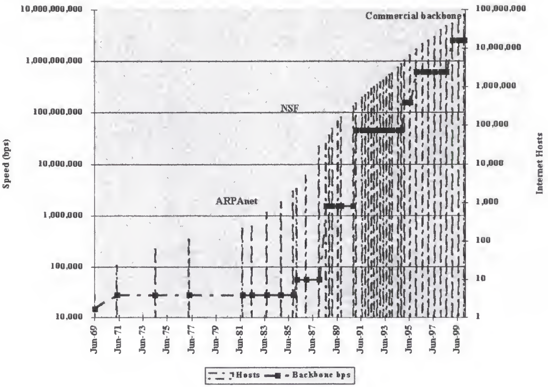

Figure 4-55: Growth in Internet hosts and backbone speeds, 1969-2000 (log scales)

It took ARPA four years (from 1965 to 1969) to launch the original nodes at UCLA, Stanford, UCSB, and the University of Utah [Zakon, 1997].

The next step in the Internet's evolution from a federal defense project (ARPANet) to a commercial network came in 1983 when ARPANet was split from MILNET, which became a US DOD-only Intranet. Next, in 1986 NSFNET was created when the NSF (National Science Foundation) funded research in packet networks. Over time, NSF became the main agency responsible for the Internet. The NSF's role was to encourage exchange of research and ideas through Internet use by universities, scientists, and other professionals who used computers.

However, the Internet backbone outgrew NSFNET, growing from 56 kbps in 1985 to T-1 (1.544 Mbps) in 1988, and then to T-3 (45 Mbps) in 1991. In 1993, NSF created InterNIC to provide domain registration and other services. By 1995, NSFNET became a research-only network and most US traffic was routed through network providers such as MCI and AT&T with backbone data rates of 155 Mbps. The Internet was begging to become commercial.

Now, the Internet has a few dozen "Tier 1" carriers (also called NSPs, Network Service Providers), many with their own fiber optic backbones reaching up to OC-48 (2.48 Gbps) [Tower, 1999]. Tier 1 carriers have peering agreements with one another and with smaller ISPs to exchange traffic. Much of this exchange occurs at NAP (Network Access Points) such as MAE-East in Maryland and MAE-West in California. A recent proposal by Governor Bush calls for the establishment of a NAP in Florida. Many NSPs and ISPs already have substantial access points in Tampa, Miami, Orlando, Jacksonville, and Fort Lauderdale to carry traffic to and from Florida and certain points in the Caribbean and Latin America.

Internet services and technologies involve the very heart of hypercommunications. No other hypercommunication markets price services in such lumpy and un-standardized ways or have such diverse, rapidly changing technologies. Before discussing this point further, an overview of the Internet services and technologies to be covered in this section is made in Table 4-30.

With the list of Internet services and technologies in Table 4-30 already somewhat familiar, it would be easy to assume that most businesses are already using these tools to innovate and compete. However, while over half of Florida's 475,000 small businesses use the Internet, most:

> . . . use it in a rudimentary way, because only about 10 percent use the Net for regular transactions with customers or suppliers, the applications that create efficiencies, cut costs, increase productivity, and improve service to customers. [Ackerman, 1999, p. 4]

Ackerman and others see the real potential of the Internet as a communications tool for small businesses (like many agribusinesses) with a significant potential for economic growth for businesses that take advantage.

Table 4-30: Internet services and technologies.

Service or Technology	Sec.	Description	Recent developments important to agribusinesses
Internet access & transport	4.9.1	Access connection used to reach the Internet. Carriers include ISPs, OSPs, NSPs, ILECs, ALECs, and IXCs.	Introduction of high-speed wireline and wireless access in many areas of Florida, SLAs.
E-mail	4.9.2.	Electronic mail, auto-responders, USENET & other newsgroups, LISTSERVs, spam filters.	Maintaining productivity while avoiding viruses and spam. Avoiding e-mail overload, prompt responses to customer inquiries.
Domain names & DNS	4.9.3	Commercial web addresses and numeric IP addresses for business network.	Domain naming strategies, new kinds of top and mid level domains, IP addresses.
Web hosting	4.9.3	Make or buy decision regarding where to have agribusiness' site(s) hosted.	Self-hosting, hosting with a hosting firm, server co-location.
Website design & maintenance	4.9.4	Make or buy decision regarding creation, updating, and maintenance of web sites and links.	Website as salesman, advertisement, PR vehicle, personnel recruiter, employee morale booster, in-house organ, & investment solicitor.
Website statistics & measurement	4.9.5	Make or buy decision regarding cost benefit analyses of websites, management of databases, traffic loads, and security testing.	Measuring web site and web promotion effectiveness, visitor data.
Web promotion	4.9.5	Make or buy decision regarding drawing traffic to website through search engine & directory listings.	Promotion of site to search engines, link exchanges, etc. Creation of online relationships & strategic partnerships.
OS & IP apps. & utilities	4.9.6	FTP, Telnet, shell accounts, other OS commands. UNIX, NT, Linux hosting.	Server operating system and hardware determines choice of applications, etc.
Convergent apps. & VPNs	4.9.7	Internet convergence: telephony, video conferencing, & secure data networking.	Internet as hypercommunications network: can the 'net provide every communication service?
System security	4.9.8	Prevent loss of corporate secrets, avoid unauthorized access, hacker/vandal attacks, viruses, etc.	Prevention of denial of service attacks, hackers, vandals, & viruses. Protection of price and other information. Intranets & Extranets.
Privacy & use policies	4.9.8	How customer data will be used. Internet use policies for employees.	Customer and employee privacy.
E-commerce & customer service	4.9.9	Online shopping, ordering, payment. B2B and retail.	Interactive real-time auctions, margin squeezes, maintenance of distribution channels.

4.9.1 Internet Access and Transport

The first important aspect of the Internet market is access. Internet access refers to the connection or loop an agribusiness firm uses to reach the POP of an Internet provider. As with other forms of hypercommunications, Internet access may be wireless or wireline. Since agribusinesses are assessed two charges for Internet service, it is common to consider Internet access from the point-of-view of both the backbone connection (ISP charge) and the access level connection (carrier charge).

Figure 4-56 depicts the typical situation. The access level connection is over the local loop from the agribusiness location to the ISPs POP. In the simplest case, access is over a POTS telephone line used by a modem for dial-up Internet access. The backbone connection refers to the connection from the ISP to the Internet. The ISP may purchase the backbone connection from an NSP, a larger ISP, or another carrier.

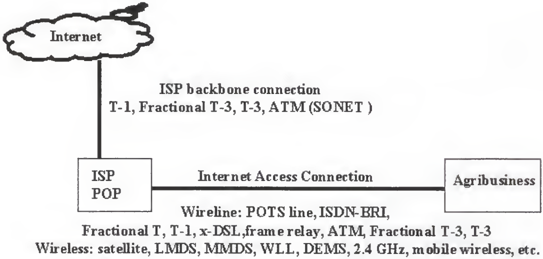
Internet
ISP backbone connection
T-1, Fractional T-3, T-3, ATM (SONET)
ISP
POP
Internet Access Connection
Agribusiness
Wireline: POTS line, ISDN-BRI,
Fractional T, T-1, x-DSL,frame relay, ATM, Fractional T-3, T-3
Wireless: satellite, LMDS, MMDS, WLL, DEMS, 2.4 GHz, mobile wireless, etc.

Figure 4-56: Internet access and backbone loops.

In the simplest case, a dial-up customer pays the telephone company a monthly fee for the telephone line along with any toll charges for the time the modem is connected to the ISP's modem bank. Dial-up customers of the ISP pay the ISP a charge for Internet access, typically a fixed monthly charge for unlimited use. Hence, there are two charges: one to access the ISP and one to access the Internet.

Agribusinesses may use a number of methods to access the Internet beyond a simple modem over an analog telephone line. Internet access methods are summarized in Table 4-31. The technical details of each kind of connection have been discussed at least once elsewhere as noted in the table. However, all Internet connections connect the agribusiness to the ISP POP. Typically, there is a fixed monthly Internet access charge which (while based on the capacity of the ISP POP to agribusiness premises connection) is really a charge for the Internet that the agribusiness uses on the ISP to Internet (NAP). Just as dial-up users pay for both a telephone line and an Internet connection, other wireline forms of Internet access may incur a second charge for the access connection, which is purchased from a telco or cableco. At this stage, the discussion does not include access and backbone connections for agribusinesses that host their website on their own premises; that point will be covered in 4.9.3.

Depending on conditions at the ISP, the access connection provider, or the Internet itself, the throughput rate from the agribusiness to the Internet may or may not be equal to the capacity of the access connection at a particular time. For example, if an agribusiness purchases a T-1 dedicated access connection, it might find that it would fail to obtain that data rate between the ISP and the Internet NAP. This situation could occur for several reasons.

First, an ISP (like other communication providers) estimates demand for its own backbone connection to the Internet based on the probable customer traffic loads. Just as with line consolidation in the local loop (where perhaps eight to sixteen telco customers out of one hundred can use the telephone at once), consolidation ratios are employed by ISPs.

Table 4-31: Methods of business Internet access.

Method	Sec.	Characteristics	Data rates (symmetric unless noted)
Dial-up	4.2.2, 4.3.2	Slow, connection establishment and failure delays.	33.4 kbps (up), 56 kbps (down)
Dedicated 56k	4.3.2	Not a modem, DDS	56 kbps
Fractional T-1 (DS-0)	4.3.2, 4.7.3	Always-on.	64 kbps, increments
T-1 (DS-1)	4.3.2, 4.7.3	May be available in dynamic, burstable form for Internet. Tier 2 ISPs may not be able to guarantee rate.	1.536 Mbps
T-3 (DS-3)	4.3.4, 4.7.3	Sold by tier 1 ISPs only.	45 Mbps
Cable modem	4.3.3, 4.7.3	Possible overbooking of shared broadband circuit.	6 Mbps (down), 1 Mbps (up), varies widely
Frame Relay	4.8.2	Full data rate not dedicated.	DS-0, Fractional T, DS-1
ATM & SONET	4.7.3, 4.8.3, 4.8.4	Becoming available to individual businesses at slower rates. Fiber optic cable and DCE needed.	OC convention, OC-1=51.84 Mbps, OC-256=13.271 Gbps, see Table 4-29
ISDN-BRI	4.7.5	Pricing can be based on time connected.	128 kbps
ISDN-PRI	4.7.5	So-called smart Ts that include PSTN, data, and Internet are ISDN-PRI	1.472 Mbps
x-DSL	4.7.3	Availability and speed are highly sensitive to distance from CO, see Table 4-21.	ADSL: 640 kbps (up), to 8 Mbps (down)
			G.Lite: 64-512 kbps (up), 1.5 Mbps (down)
			HDSL: 1.5 Mbps
			VDSL: 1-20 Mbps (up), to 51 Mbps (down)
Mobile wireless	4.4.2, 4.7.5	Subject to fading, interference, etc.	2G: 9.4-64 kbps 3G: 300 kbps-2Mbps
Fixed terrestrial wireless	4.4.2, 4.8.5	Varies depending on frequency, see 4.4.2. No need to pay twice as with wireline.	MMDS: to 10 Mbps
			LMDS: 20-50 Mbps (down), 3-10 Mbps (up)
			DEMS: To 30 Mbps
			WLL: 45-155 Mbps
			2.4 GHz: 156 kbps- 11 Mbps
Fixed satellite wireless	4.4.3	High latency. No need to pay twice as with wireline.	2 Mbps (down), 33.4 kbps (up), higher in future

In the modem case, the ISP may have from eight to forty customers per actual dial-up access line. Further consolidation occurs as the ISP plans the wholesale backbone capacity needed to reach the Internet from the ISP location. An ISP has to overbook both access traffic and backbone traffic, though the situation becomes complex when various combinations of circuit-switched, dedicated, and even packet-switched connections are considered. Generally, the ISP connection to the Internet (ISP backbone) capacity is most limited because the ISP's profits would evaporate if it assigned every customer their maximum data rate and purchased wholesale bandwidth accordingly.

However, once traffic reaches the Internet, there is no guarantee that the access rate will be reflected in the data rate experienced over network segments over the Internet and noticed by users as part of their throughput rate[38]. Hence, it can be difficult or impossible for an agribusiness to tell if the ISP has overbooked its circuits or if slow download speeds are simply a result of Internet congestion. Internet congestion in turn can be systematic or due to congestion at the distant site. The traceroute and ping utilities (see 4.9.6) or proprietary software can identify the location of a problem, but results are dependent on the site at the other end.

Another reason that the data rate of a wireline access connection may not equal the rate of an Internet download is not even within the ISP's control, nor can it be blamed on the Internet. Instead, the cause can be in the carrier's access level network. Recall that broadband transmission technologies share bandwidth among users so that if many cable modem users are simultaneously online, congestion in the access loop can slow connections down even if the cableco has ample Internet backbone capacity. Similarly, while carrierband and baseband connections are not shared, they may share ports, switches, or other intermediate DCE that can create bottlenecks.

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[38] Recall from 4.2.1, (Table 4-2) that the data rate is an error-free speed of a single DCE-DCE network link (including overhead). The effective throughput (or throughput rate) is the end-to-end (DTE-DTE) rate at which the viewer's computer system processes and transmits user information (overhead not included). Both are often popularly called bandwidth, but as 4.2 points out bandwidth, data rate, and throughput rate are separate (but related) concepts.

Additionally, noisy line conditions and or atmospheric interference (mainly in the wireless case) can prevent the access connection from attaining maximum speeds.

In addition to access, most ISPs offer various levels of access or service plans, often related to both the speed of the connection circuit and the amount of traffic from the ISP to the Internet to be expected. Table 4-32 shows several levels of Internet access.

Table 4-32: Un-standardized "levels" of Internet access

Level	Description	Characteristics	Provider type
Text e-mail	Access to text e-mail only.	Transitory dial-up connection, no IP address or web browsing.	Juno, other advertising supported providers, two-way wireless pagers
0	OSP account	Mainly not accessing the Internet, limited web browsing through OSP network.	OSP (AOL, CompuServe, Prodigy, Juno Gold, WebTV)
1	Dial-up Internet host account	Limited access.	ISP
		Unlimited access with disconnection of inactive sessions.	
2	Dial-up SOHO commercial account	Unlimited access.	ISP
3	SLIP/PPP connection	Dedicated IP address, can run any software, non-dedicated connection.	ISP
4	Dedicated node(s)	Dedicated IP address and dedicated connection.	ISP
5	Dedicated host(s)	Transport-level connection where agribusiness acts as its own ISP.	Tier 1 ISP

Importantly, some IP & OS related features are not available to certain account levels, at certain ISPs, or may be subject to extra charges. See 4.9.2, 4.9.6, and 4.9.7 for specific examples. The text e-mail level refers to providers who offer dial-up connections or wireless hookups through which text e-mail may be downloaded. Customers do not have Internet access, only the ability to receive and send e-mails. E-mail is checked during transitory sessions where users are connected only as long as it takes to send and receive their e-mail. Users read and compose their e-mail while offline. Typically, such dial-up e-mail only services are free, with costs underwritten by advertisers whose banner messages are displayed while the e-mail software is being used.

The next connection level is called level 0 to denote that it is not actually an Internet connection at all, but a dial-up connection from the user to an OSP network and possibly through that network to the Internet. AOL and other online service providers have their own Intranets (reserved for their customers) from which they receive advertising revenues and control the content and design. Much of the customer's online time is spent on the OSP Intranet, though customers can browse the Internet as well. OSP web browsers are often unable to view material on many websites, though this issue is expected to be resolved by 2001 at AOL through its Netscape acquisition. Level 0 connections may not be able to send and receive certain kinds of e-mail and do not have access to OS & IP applications and services (discussed in 4.9.7).

Level one accounts are the most common kind of Internet access. They feature dial-up access with a dynamically assigned IP address. Depending on the ISP and access plan these may be unlimited access or limited access. Limited access accounts have the right to log on for a certain number of hours per day, week, or month for a minimum monthly charge. Unlimited access accounts do not have a maximum number of hours, but pay a higher monthly charge. However, unlimited access accounts can be "timed out" if the connection is left open for a certain time without any user action. Level one accounts typically have an e-mail account at the ISP's .net or .com domain but do not have the right to store e-mail files on the ISP server. Level one access may also include shell access, limited technical support, and the ability to use news and FTP.

Level two accounts are aimed towards the SOHO (Small Office Home Office) market. While they are not truly dedicated access in the sense of having a continuous connection or dedicated IP address, these dial-up accounts can be configured in several ways that help SOHO users. One feature they include is the ability to connect to the company Intranet, WAN, and e-mail server. Level two accounts may have better technical support, a personal web page, and the right to leave e-mail messages on the ISP server up to a certain number of megabytes.

Level three accounts offer a single dial-up computer the ability to have a dedicated IP address. Therefore, such accounts are able to join VPNs (Virtual Private Networks) so that cyber commuters or small offices can be part of the company network. Level three accounts allow the user to run certain software or utilities compatible with TCP/IP to chat, exchange files, e-mail, exchange video files, or possibly to use Internet telephony[39]. Level three accounts are likely to be able to relay e-mail to the account from addresses on other domains, gain access to remote e-mail accounts, and use the full range of CGI, JAVA, and other scripts for particular applications.

Dial-up access is not necessarily a local call since it depends on how local calls are defined and how extended calling zones are constructed (see Figure 4-36 in 4.6.1). In some rural areas of Florida, dial-up access may be available only as a long-distance call. Even when available in rural areas, Internet service may not be available at 56 kbps speeds because of poor line conditions, large distances from subscribers to COs, and lack of digital lines for ISP to CO connections.

Level four accounts have a dedicated IP address just as level three accounts do, but they also have a dedicated (non dial-up) connection. With this type of account, an agribusiness is connected full-time to the Internet and could host its own website if it had sufficient capacity and the appropriate CPE. Recall that there can be a difference between the capacity of the access connection (from the agribusiness to the ISP's POP) and the backbone bandwidth (from the ISP to the Internet backbone). Most level four accounts entail a "best effort" commitment from the ISP to allow the accountholder a particular capacity from customer premises to the Internet itself.

Level four accounts require a dedicated host computer or computers so the agribusiness must maintain system software and security, upgrade applications, troubleshoot connections within the business, etc. For this reason, many smaller agribusinesses rely on a series of individual dial-up accounts rather than having their own host server. Level four accounts can often drop the monthly cost of Internet access (both ISP and access connection bills) for agribusinesses with many level zero through level three accounts, but there are higher setup costs. If the agribusiness has its own website, VPN, Intranet, or is required by suppliers or customers to have Extranets, a level four account can make a great deal of sense. More discussion about web site hosting (and level four access) is found in 4.9.3.

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[39] See 4.9.6 for more examples and a discussion of how some Internet services (beyond e-mail and WWW) are not available through certain ISPs, or if particular Internet server software or operating systems are used.

The final kind of account, level five, is not an ISP-style account at all. Here, the agribusiness acts as its own ISP with a direct connection to the Internet. Such a solution is not practical for all but larger agribusinesses and will always involve consideration of web hosting and other Internet services. Level five access could be obtained through a Tier 1 ISP via a direct link to facilities owned by that firm.

Internet access may include recurring monthly charges, usage based fees, as well as one-time installation and equipment costs. There will always be one charge for the access connection (often paid to an ILEC or ALEC) and another charge for the Internet access itself. Recurring charges are typically based on the capacity of the access connection (for example a set charge monthly for a T-1 connection). However, some access plans include charges for the amount of traffic transported as well. This becomes a particularly important issue if the agribusiness hosts its own web site. Internet connections require the appropriate CPE and edge devices needed for the access connection as well as routers and specialized servers and software that might be needed.

As was mentioned in 4.8.6, managed services such as managed router services and other features may be arranged for separately with carriers for Internet service just as with private data networking. Outside firms can be hired to manage routers, servers, and security. The need for security policies is returned to in 4.9.8.

Florida has had its share of innovative Internet companies. For example, Cybergate of Broward county (now E-spire) began Florida's first cyber store in 1992 with a Gopher site called

CyberStore on the Shore [Resnick and Taylor, 1995, p. 384]. Since then, the ISP market has experienced dramatic growth along with major structural changes. While the market has seen numerous mergers and acquisitions in the last two years, there are still over a thousand ISPs that are active in parts of Florida. The Tier 1 ISPs (also called NSPs) that are active in Florida, along with costs and availability, are covered in Chapter 7.

4.9.2 E-mail

It should be emphasized that the Internet is a communications medium, not simply an advertising medium for web pages. A single e-mail is far less expensive than a personal sales call, snail mail business letter, or local or long-distance telephone calls. However, some businesses almost ignore e-mail when communicating with customers.

E-mail's potential importance has been widely discussed:

> According to Book Marketing Update in Fairfield, Iowa, as much as 75% of business-to-business correspondence will take place by fax or e-mail by the year 2000. Probably half of all consumer-to-consumer and business-to-consumer correspondence will be through fax or e-mail, predominantly the latter. [Resnick and Taylor, 1995, p. 377]

While this prediction has not yet become true, an enormous amount of e-mail is sent. According to one source, the total volume of U.S. e-mail surpassed one trillion pieces in 1998 [Ackerman, 1999]. By mid-1999, the number of e-mails sent each day in the United States is over 9.4 billion. However, over seven billion of those messages represent spam or unsolicited junk e-mail [*Internet Week*, February 8, 1999, p.17]. Other sources such as the firm eMarketer.com suggest that spam comprises fewer than ten percent of all e-mail messages.

E-mail has become more versatile if defined to include interactive messaging and chat:

> For many Internet users, electronic mail (e-mail) has practically replaced the Postal Service for short written transactions. Electronic mail is the most widely used application on the 'net. You can also carry on live 'conversations' with other computer users, using IRC (Internet Relay Chat). More recently, Internet telephony hardware and software allows real-time voice conversations. [www.whatis.com/internet.htm, p.1, last updated 10/13/98]

When Queen Elizabeth sent her first e-mail in 1976, most e-mail services were within closed networks. Telnet (the first public, closed) packet data service was opened by BBN in 1974 [Zakon, 1997, p.3]. It would not be until the 1990's that business e-mail could travel among different packet data services, which by then included OSPs AOL, CompuServe, and Prodigy. USENET newsgroups were begun in 1980 at Duke University and UNC.

E-mail services and technologies include such things as multiple addressing, auto-responders, LISTSERVs, web forms, and e-mail enhancements such as voice and video. E-mail can be delivered to wireless handheld devices, pagers, fax machines, and mobile telephones in addition to computers. Voice-to-text technologies exist so that e-mail is now accessible from any telephone in the form of a computer device speaking aloud text messages. Voice responses can even be converted into text e-mails via telephone or desktop and sent via the Internet to any e-mail address. Faxes can be converted into e-mail and e-mail converted into faxes.

E-mail reaches an agribusiness from its ISP, OSP, NSP, or e-mail service provider. Level zero through level three Internet access includes e-mail from the ISP, but agribusinesses with level four or five access may use a specialized e-mail service provider or have their own on-site e-mail server. Whichever is the case, it is important to configure the e-mail system carefully. Unless level three or higher Internet access has been purchased the agribusiness may only get a single e-mail address per Internet account. Some ISPs will allow more than that number, some will not.

This sub-section covers four major issues regarding the use of e-mail in agribusinesses. First, one important use of e-mail within a business is as a sales or communication tool. If the accounting costs of a message are considered, sending an e-mail is far less expensive than sending a fax, writing a business letter, mailing out sales literature, or making a long-distance call. However, there are social and economic implications to be kept in mind as well that currently limit e-mail's usefulness to agribusinesses.

E-mail has several characteristics that make it an excellent communications tool. One of these is the instantaneous nature of e-mail. This can be an excellent feature, as for example, when communicating with overseas customers or suppliers at a tiny fraction of the cost of an overseas telephone call. However, since it is almost instantaneous, e-mail also leads to the expectation that e-mails sent to an agribusiness will be answered quickly. It is particularly unprofessional looking to computer savvy customers if an agribusiness answers their e-mails so slowly that a snail mail (regular postal) letter would have obtained faster results. It is common for e-mails to companies to go completely unanswered. This is particularly unforgivable given that in many of these cases no expense has been spared to connect the firm to the outside world via state-of-the-art networking technologies and e-mail inquiries come in daily from an elaborately designed web site. The agribusiness must make sure to change job descriptions and responsibilities so that someone in the firm is responsible for e-mail.

A second issue about e-mail concerns some of the dangers (real or imagined) of e-mail use. E-mail has been criticized as to its usefulness in business because of characteristics such as being impersonal, unreliable, quasi-anonymous, and without legal standing. There is some truth to each accusation, but agribusinesses can adopt prudent strategies for dealing with each one as technology improves e-mail further. E-mail does not have to be impersonal if the agribusiness personalizes responses. The reliability of e-mail messages is not perfect, but by shopping around for a high-quality ISP or mail server, many problems can be prevented. For greater security, e-mail can be encrypted and return receipt features can give some idea of whether messages that are sent out are received.

While e-mail is a mission critical application for many businesses today, it can still be unreliable. Of particular importance is the ability to retrieve e-mail if a mail server or access connection goes down. There may be no way (other than possibly through exhaustive research) to tell whether a particular ISP's e-mail handling is likely to fail. However, e-mail designated for the agribusiness should be automatically removed from the e-mail server and placed on a local machine or LAN server at the agribusiness location automatically as a matter of course.[40] If there is a connection problem, a redundant method of e-mail access (such as a dial-up line, etc.) should be ready and available to use to provide redundant ability to download personal and organizational e-mail. The importance of e-mail suggests that each agribusiness automatically backup e-mail messages as well so that if a machine crashes or an employee leaves there will be a record of correspondence left behind.

It is true that the identity of a person is not established absolutely by an e-mail address. Of the approximately 80 million Americans who have ever used e-mail, each has an average of almost three addresses. Free e-mail services such as hotmail, Juno, and Yahoo! mail are both notorious for making it easy to camouflage customer identities. It is certainly possible that competitors can pose as customers in e-mails or other subterfuges may be used. That is why proper Internet use policies (to be discussed more in 4.9.7) are important. Employees should understand that even when they are sure of the identity of an e-mail correspondent unencrypted mail could still be intercepted. When unsure of an identity, discretion should be used.

The legal standing of e-mail comprises at least two issues. First, as the Clinton administration found, even deleted e-mails can return to haunt their authors. E-mails that detail illegal activities, sexual harassment, racial discrimination, or other practices can be used as evidence against the company [Overly, 1999]. A second issue concerns whether e-mail carries the legal weight that a letter does. New digital signature technologies can be used to give an e-mail signature the weight of a paper signature for many domestic business transactions. However, an attorney should be consulted for specific advice.

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[40] However, for users that move from home computer to office to laptop (or for users who use different computers as they travel from office to office) the standard POP protocol may not be the best one. IMAP may be a better choice. These and other Internet protocols and utilities that may or may not be available with certain ISPs or server operating systems are discussed in 4.9.6.

With these caveats in mind, e-mail does have many uses, especially if the audience is computer literate, responding from the Internet, and employees are groomed to use it regularly. According to empirical studies by Kraut and Attewell, "employees who used e-mail extensively, net of their communications over other media, were better informed about their company and more committed to its management's goals" [Kraut and Attewell, 1997, p.323]. Many Florida agribusinesses report interstate and international inquiries and orders because of the low cost of e-mail communication and positive symmetry with web sites.

A third issue concerns the uses of internal e-mail for the agribusiness. Employees can be kept advised of day-to-day happenings, new products, and other company news. A single e-mail can be automatically sent to every employee in the company with little effort. This can be a double-edged sword because if employees are bombarded with too many in-house messages of various degrees of importance to them, they may end up not reading any "internal spam" [Anderson, *et al.*, 1997]. One firm found that as many as twenty separate employee e-mailings were indiscriminately sent out each day resulting in less employee knowledge rather than more since over thirty minutes of employee time was spent in wading through the messages. That practice was replaced by a daily e-mail list (with items targeted to specific groups) so that at most each employee got a single e-mail with items personalized to their job description. Not surprisingly, the new daily newsletter e-mail achieved better readership.

A fourth thing for agribusinesses to realize about e-mail is that e-mail includes many kinds of message services. If an agribusiness hosts its own e-mail domain (has level four or level five access), its e-mail options will depend on the software included with the e-mail server. If the agribusiness has a series of individual dial-up accounts, it may have to pay extra for certain e-mail services if they are available at all. E-mail addresses fall into two categories. The first type are user name addresses that correspond with an Internet (or private data network) user's name. The second type is alias addressing. Alias addressing allows e-mails addressed to virtual addresses such as sales@agribusiness.com or info@agribusiness.com to be received by the appropriate person in the organization.

Other e-mail services include auto-responders, LISTSERVs or mailing lists, and even specialized programs that filter out spam or automatically route e-mails. Auto-responders are programs that automatically respond to any e-mail message sent to a particular address. The typical form of an auto-response is to acknowledge receipt of the original message, along with a promise to respond quickly or a list of contact e-mail addresses in the company. Unless accompanied with sophisticated technologies capable of analyzing the subject of a message, auto-responders are meant only to acknowledge the receipt of an e-mail and assure a correspondent that a personalized response is on the way. Some organizations use auto-responders to form reply to all e-mails, forcing the correspondent to e-mail a response before reaching a human being. This can annoy customers.

Auto-responders are also used with webpages and HTML forms to send customers more information automatically. For example, if after having read a website description of products A, B, and C, a prospect fills out a form requesting detailed information on product A, an auto-responder can send a form letter out with the information needed. This action is most effective when a copy of the inquiry is auto-forwarded to the sales department so a salesperson can contact the prospect later to close the sale or make sure that the information was satisfactory. It is customary to find out from the prospect on the web site form what the desired form of response (telephone, e-mail, letter, personal visit) from the company (beyond sending the information) would be. That way, prospects are not hounded by unwanted telephone pitches or spam.

LISTSERVs and mailing lists are e-mails sent by the agribusiness to many e-mail addresses all at once. LISTSERVs are specialized discussion or announcement lists that customers explicitly subscribe to, typically from a website. Mailing lists include the addresses of customers who have requested to be periodically updated about new products and pricing, or to receive newsletters or catalogs. It is preferable that the agribusiness obtains the e-mail addresses for mailing lists with the customer's permission (to do otherwise will risk angering customers with spam). Once the e-mail addresses have been voluntarily obtained it is better to avoid burying the mailing list with a blizzard of e-mail. For example, subscribers to one firm's LISTSERV got an average of seven e-mails daily from that company while a mailing list from another firm resulted in over 100 e-mails in three months. Privacy of customer e-mails, e-mail addresses, credit card information, and other data should be the subject of an explicit privacy policy. This subject is returned to in 4.9.8.

Another kind of e-mail service is spam filtering and correspondence filtering software. Many e-mail packages offer limited spam filters and special packages can be obtained that filter spam out as well. Unfortunately, these packages can also filter desired messages as well. Correspondence filtering software takes messages that come into main e-mailboxes for a firm and automatically attempts to route them to the appropriate person in the organization. Such packages are expensive enough ($50 to $75 thousand) that they are priced beyond the budgets of most agribusinesses.

4.9.3 Domain Names, IP Addresses, and Web Site Hosting

While the Internet has many other communications uses for agribusiness, it is often erroneously considered as a synonym for the World Wide Web (WWW) and specifically for business web sites.

> The most widely used part of the Internet is the World Wide Web (often abbreviated 'WWW' or called 'the Web')....
>
> Using the Web, you have access to millions of pages of information. Web 'surfing' is done with a Web browser, the most popular of which are Netscape Navigator and Microsoft Internet Explorer. The appearance of a particular Web site may vary slightly depending on the browser you use. Also, later versions of a particular browser are able to render more 'bells and whistles' such as animation, virtual reality, sound, and music files, than earlier versions. [www.whatis.com/internet.htm, p.1, last updated 10/13/98]

In March 1995, web traffic surpassed FTP (File Transfer Protocol) requests as the main source of Internet traffic. Now, about 75 percent of Internet traffic is WWW [Ebbers, 1999]. The importance of the web site to agribusiness communications, marketing, and advertising strategies lies in several related areas.

First, the agribusiness must choose domain names and make a determination as to where to host the web site(s) associated with each domain name. Second, based on the Internet access decision, e-mail choices, and web hosting decision, there will be one or more IP addresses assigned to the organization. These two topics are covered in this sub-section.

However, the discussion of the importance of the web site to an agribusiness does not end there. Web site design and site maintenance are topics in 4.9.4, while web site promotion and measurement are mentioned in 4.9.5. Of course, no single part of the Internet area is entirely divorced from the web site since Internet access (4.9.1) and e-mail (4.9.2) decisions are likely to involve the web site as well. E-commerce and customer service (4.9.8), security and privacy policies (4.9.8), and broadcast content production (4.9.10) also stem from the web strategy.

Given the importance of web sites to overall success on the Internet, it is surprising how little attention is paid to the cheapest element (some would say the most important) of a business Internet strategy, the choice of domain names. Every address on the WWW (it will be remembered from 4.5.2) uses the HTTP (HyperText Transfer Protocol) to transfer an IP address into a recognizable domain name. Under Internet Protocol version 4, an IP address is "a set of four 'octets', or 8 bit numbers from 0 to 255, separated by periods, that define a unique host on the Internet." [Israel, 2000, p. 5] Internet hosts include CPE edge devices, DTE, and a variety of routers and intermediate DCE at the local, access, and transport levels. Instead of having to type in the quad notation http://207.30.45.101 to reach the A. Duda and Sons corporate website, all an Internet viewer needs to do is type in www.duda.com in the location bar of their web browser.

Before discussing domain name strategies, it is necessary to develop the uses of IP addresses in general and apply them to agribusiness needs. A shortage of addresses along with other concerns has led to the development of newer 128-bit IP addresses in IPng (IP next generation or version 6). The new protocol has 4 billion times 4 billion more addresses than version 4, so that it is less likely addresses will become in short supply. IPng is expected to increase the almost exhausted supply of certain kinds of IP addresses in the near future. For agribusinesses now, version 4 addressing is the rule.

Agribusinesses may use IP addresses for websites and (if they have level four or level five access) for some or all CPE (both DTE such as computers and DCE such as routers or specialized servers) on their own premises. IP addresses are assigned by classes as shown in Table 4-33.

Table 4-33: IP version 4 addresses.

Class or type	Prefix.0.0.0	Nodes on sub-net	Owner	Location
Web site address	Varies	1	ISP or web host	ISP if sold alone
Class C	192-233.n.n.local	254	Small organization	Business premises
Class B	128-191.n.local.local	64,516	ISP or large organization	Network
Class A	0-127.local.local.local	16,777,214	NSP or	Network
Un-routed IP addresses	10.0.0.0 to 10.255.255.255	16,777,214	Internal LAN or WAN	Not directly on Internet
Class D (multicast)	224.0.0.0 to 239.255.255.255	Varies	Selected web hosts	ISP equipment and CPE

If the agribusiness has dial-up Internet access with IP addresses for computers that access the Internet assigned dynamically, the only IP address it owns is the web site address. Often, a smaller agribusiness will have but one or two dedicated IP addresses (rented from an ISP) with level three or higher Internet access. With level four or five access, the agribusiness may have one or more class C address blocks for routers, e-mail servers, gateways, and even for individual workstations in some cases. The agribusiness' addresses will be of the quad notation form C.network.network.local where C indicates a class C prefix, n denotes network levels (such as NSP and ISP) and local indicates machines on their own network. Class B addresses are typically assigned to ISPs or large organizations such as state governments or universities. Quad notation for class B addresses will be B.network.local.local to show that Class A addresses are typically held by national governments, the military, or NSPs (Tier 1 ISPs). Class D (multicast) addresses are discussed in 4.9.10.

To be connected to the Internet, a particular computer or device at an agribusiness is often behind a proxy server, DHCP server, or firewall so that it uses the last entry in Table 4-33, an un-routed IP address. Such un-routed IP addresses obtain pseudo-anonymous Internet access in several ways. First, they may use DHCP (Dynamic Host Configuration Protocol) where workstations share locally assigned IP addresses with each other. When DHCP machines communicate with the Internet, a DHCP server assigns an available IP address (from the set exclusively available to the firm) to the machine temporarily. Idle machines do not take up IP addresses if DHCP is used, therefore conserving an organization's class C addresses. Proxy servers are another way for machines with un-routed IP addresses to communicate over the Internet. Proxy servers operate on a small block of IP addresses, and can act as firewalls, news, mail, and web servers while providing proxy connections for hundreds or thousands of internal users [Israel, 2000]

Returning to the subject of website addresses, agribusinesses can have multiple domain names pointing to the same web site. In this way, when web viewers enter variations of the domain name, common misspellings, or product names they automatically reach the intended site. Often, names are held in reserve so that the company will have its corporate name, trade names, product names, and the names of associated ventures protected. For example, Duda and Sons owns two other names, viera.com for the residential community it is developing (Viera, Florida) and redicel.com for Duda's Redicel brand of processed celery. Currently, Duda operates both the main Duda site and a separate site for Viera, but the redicel.com domain name is parked and registered.

Registering a web domain name makes sense for $30 to $50 per year (and as low as $200 for 10 years). This is a small price to pay to ensure that brand names for future web sites remain available for the agribusiness to use. Domain name parking is often sold as a monthly service by ISPs, who may charge up to $30 per month to guarantee that a particular reserved name will not be stolen if it is not used. Generally, the parking of a domain name with an ISP is not necessary to retain it.

Complicated legal questions are involved if individuals buy domain names in hope of selling them to companies that have legitimate claim via trademarks or other legal rights to the name. This practice is known as cybersquatting and legislation has been enacted recently to prevent the practice of purchasing protected domain names solely for resale (often for extremely high prices) to the party with legal right to the name. Before the law, Harley Davidson motorcycles purchased the hardleydavidson.com domain from a Michigan dealer for an undisclosed sum. Until then, the main corporate website was found at harley-davidson.com. Domain brokers can do an excellent (and legal) business trading in non-trademarked domain names. Recently, egg.com was sold by a U.S. broker to Prudential for over $100,000. If an agribusiness finds that its legal operating name is being "held hostage" by an individual who registered the name years ago in hopes of selling it to the agribusiness, the agribusiness may be able to take legal action.

In other cases, another organization may have been making legitimate use of the name and an agreement may be made that is satisfactory to both parties. Archer Daniels Midland (ADM) uses admworld.com as its main corporate site but allows adm.com (which it also owns) to be used by the American Direct Mail Corporation. ADM (the agribusiness) also owns the following domain names: adm.com, ad-m.com, admhold.com, admweb.com, admgrain.com, novasoy.com, admhealth.com, admfood.com, admfeed.com, and marthagoochpasta.com, d-alpha.com, nutrasoy.com, and many others. Multiple domain names are frequently held in reserve so that various divisions of the firm may eventually have their own web site or e-commerce presence. Small agribusinesses can easily afford the price of registering more than one domain name. It is far easier to protect a name by registering it first than to attempt to deal with a cybersquatter through the courts or lose a profitable non-protectable domain name idea to a competitor.

A popular tactic is to register domains based on non-trademarked keywords that consumers use themselves when searching the web. This approach can often help a web site become more easily found by viewers and more easily promoted to search engines as well. Some agribusiness examples include: grocer.com (a site selling links to online grocers), nursery.com (the website of Minnesota's Bailey nurseries), wool.com (Woolmark), lettuce.com (Nunes Company), beef.com (Big Sky Beef Co-operative of Montana), florida-oranges.com and floridaoranges.com (Bob Roth's New River Groves), florida-juice.com (Key West, Inc. of Fort Myers), and floridajuice.com (Department of Citrus).

From these examples, it can be seen that there are many possible combinations of domain names. Formerly, domain names were restricted to 26 alphanumeric characters or less, but recently, domains of up to 63 characters have been registered. Domain names cannot consist of numbers alone nor have any non-alphanumeric character other than a dash. Long domain names may have multiple dashes to make them easier to enter, but it is generally better to keep the name short. In some cases, extremely long domain names cannot be reached from all computers on the Internet and may not be searchable by certain search engines.

Domain names are divided into top-level domains (TLDs), and at least one (but often more than one) sub levels called second and third-level domains. For example, in the site address http://www.farmphoto.com, the .com is the TLD, farmphoto is the second level domain, and www is the third level of the domain name. The most frequently seen TLDs are shown in Table 4-34.

Table 4-34: Top level domain name categories.

TLD Suffix	Traditional use	May U.S. agribusinesses obtain?	January, 2000 distribution
.com	Commercial businesses.	Yes.	24.8 million
.net	Networks such as ISPs.	Yes.	16.8 million
.org	Non-profit organizations.	Yes, whether co-ops or not	1 million
.gov	U.S. government agencies.	No.	0.8 million
.edu	Educational institutions (two and four year higher learning).	No.	6.1 million
.mil	U.S. military.	No.	1.7 million
.us	U.S. geographically identified names.	Yes, but only in combination with US domain naming structure.	1.9 million
.jp	Japan.	Not as TLD unless has Japanese division.	2.6 million
.to	Tonga.	Yes.	4,000
.cc	Cocos (Keeling) Islands.	Yes.	4,000
.tv	Tuvalu.	Yes.	2
.int	International organizations.	Possibly co-operatives.	8,700

Sources: ISC Domain Survey, January 2000, www.isoc.org.

Most agribusinesses try to choose simple names such as businessname.com, business-name.com, but since there are over 24 million .com TLD addresses already, it is often necessary to select a different TLD. Traditional restrictions on .net and .org registrations have been lifted so that now U.S. agribusinesses may choose businessname.net or businessname.org. However, many of the descriptive second-level domain names such as beef have already been taken. For example, Beef.com is owned by the Big Sky co-operative as mentioned above, beef.org is the National cattleman's Association site, and beef.net is owned by Web Magic of Pasadena, California.

An agribusiness wishing to use beef as its second level domain would still be able to register as beef.cc, beef.to, or beef.tv or use other TLDs from countries that are willing to sell to foreign firms. A cottage industry has sprung up in several developing nations selling domain names, but do not expect that beef.jp (Japan) or beef.ca (Canada) would be so easily purchased since each country determines its own policy. The .us TLD could be used, but only if the agribusiness (whether located in Ona, Florida or not) registered as beef.ona.fl.us or used some other location.

Another option is to use the desired second-level domain name as a third level domain name through arrangement with an ISP or web hosting company. To return to the beef example, the result would be beef.ispname.net or beef.hostco.com. If the agribusiness has reserved the appropriate domain name(s), the next decision is how to host the web site. Once the domain name(s) have been chosen, they must be registered with an approved domain registry such as www.networksolutions.com or through the ISP or web hosting company.

The decision of where to host an agribusiness' web site is a classic make (self-host) or buy (use a hosting company) decision with a third option, collocation. Figure 4-57 illustrates three main options. Dotted lines show connections over which viewer-website traffic flows while bold lines show connections that carry normal agribusiness Internet traffic.

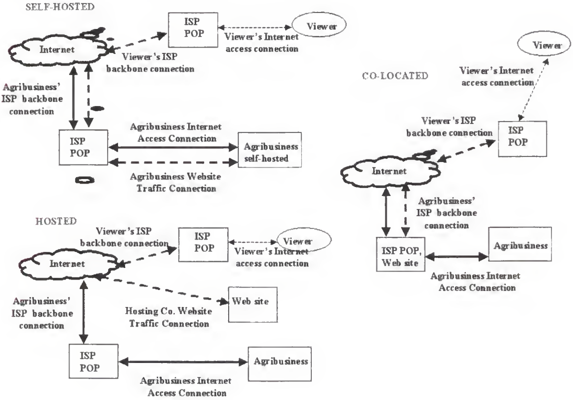
SELF-HOSTED
ISP POP
Viewer
Viewer's Internet access connection
Internet
Viewer's ISP backbone connection
Agribusiness' ISP backbone connection
Agribusiness Internet Access Connection
ISP POP
Agribusiness self-hosted
Agribusiness Website Traffic Connection
CO-LOCATED
Viewer
Viewer's Internet access connection
Viewer's ISP backbone connection
ISP POP
Internet
Agribusiness' ISP backbone connection
ISP POP, Web site
Agribusiness
Agribusiness Internet Access Connection
HOSTED
Viewer's ISP backbone connection
ISP POP
Viewer
Viewer's Internet access connection
Internet
Agribusiness' ISP backbone connection
Hosting Co. Website Traffic Connection
Web site
ISP POP
Agribusiness
Agribusiness Internet Access Connection

Figure 4-57: Web site hosting options.

In each case, to reach a website, the end-user (also called a viewer or visitor) types a URL (domain name) in their browser's location field. The end-user's ISP finds the IP address associated with the URL from a primary DNS (Domain Name Server) located on the Internet. Next, the IP number given by the DNS server is used to request the default HTML web page (typically called the index.html file) the IP address points to. That file is sent (in packets) back to the IP address associated with the end user.

Dotted arrows show how web site traffic traverses the Internet under the three hosting options. Note that for all three options there are at least seven points (called hops) that handle the WWW request for web sites hosted at the agribusiness. Each of these represents a possible congestion bottleneck that can slow the transfer down. The agribusiness has control of at best two of these.

The first connection is the viewer's own access level connection to the end-user's ISP. If the access line is noisy (such as a rural POTS line) or overbooked (such as a broadband cable connection) the website may not load quickly. The next potential bottleneck is at the ISP's POP where routers or other equipment can also slow the transfer. A third path taken is over the viewer's ISP backbone connection to the Internet. If this connection is congested, again the website contents may display slowly on the end user's machine. It is often the case that the ISP passes off traffic to several hops before a NAP (Network Access Point) actually reaches the Internet since many ISPs resell capacity of larger ISPs or NSPs (Tier 1 providers). These intermediate hops can further delay transmission.

Once the message reaches the Internet, it is transferred from one NSP to another through peering agreements. A number of intermediate stops again occur, with each hop representing another possible slowdown. Then, at a NAP serving the NSP which the agribusiness' ISP uses, the traffic leaves the Internet, possibly traveling through an additional number of potentially congested hops before reaching the agribusiness's ISP POP. Next, the web page request travels over the agribusiness's Internet access connection (or specialized web site access connection) to reach the web site if hosted at the agribusiness's location. It is up to the agribusiness to select an access connection for website traffic that is capable of handling traffic loads.

It can be easy to over or under estimate traffic levels. One celebrated case occurred when the house.gov site issued the famous Starr report concerning President Clinton. The volume of requests (over 22 million users from 11 a.m. and 4 p.m. on September 11, 1998) caused msnbc.com, cnn.com, yahoo.com, and the house.gov web site to all crash. Typically, this volume of traffic will not be seen at most agribusiness sites. However, too small a connection can easily be overwhelmed.

It is time to consider the three web hosting options in more detail. First, the firm can purchase a web server for use on its own premises, lease an Internet connection designed to handle inbound traffic level to the site, and set up the appropriate security policies (upper left of Figure 4-57). Second, the firm can lease space from an Internet hosting company on their server, based upon the hosting company's backbone capacity and expertise with websites (right middle of Figure 4-57). Third, the firm can purchase its own server and house it (collocate it) at an ISP's premises, based upon the ability to access the server for maintenance and the security of the collocation arrangement (bottom left of Figure 4-57). Each approach has advantages and disadvantages.

The do-it-yourself approach requires that the agribusiness closely monitor its own website at its own premises. Depending on the access connection and whether the ISP offers an SLA (Service Level Agreement or guarantee of traffic capacity), the Internet connection purchased will not be shared with other customers of a hosting company. However, it will be shared with other customers using the ISP's backbone. One advantage (and additional responsibility) is that Internet traffic can be monitored for security and adequacy by agribusiness personnel without using middlemen.

However, the do-it-yourself approach also requires that the agribusiness be capable of calculating traffic adequately, monitoring security, hiring appropriate network staff, and providing fault tolerant equipment to prevent the site from going down during power outages and other events. Should the site become more popular than expected, the agribusiness may have to upgrade the web server or the Internet connection (or both) to handle the increased traffic. Should the agribusiness overestimate web traffic, it may be stuck with an enormous amount of unused capacity. Costs will include initial set-up and purchase of a web server, with the recurring cost of the Internet connection from the business to an ISP (or NSP) to reach the Internet. Unforeseen expenses include having to bring in outside help to correct software, hardware, and security problems. For agribusinesses in rural areas, there may not be sufficient infrastructure to adequately self-host.

For self-hosted businesses, there can be a variety of administrative details involved in making sure domain name(s) point to the correct IP address and are renewed in a timely manner. When it hosts a site itself, a hosting ISP is not providing security, troubleshooting, or environmental protection (such as lightning arrestors and backup generators). The agribusiness has to handle such details twenty-four hours a day, seven days a week. The agribusiness must defend the site from hackers, reboot the server if it goes offline in bad weather or crashes due to software or hardware problems. Most hosting companies offer logs and statistics to hosting customers at no charge. When sites are self-hosted, statistics and log programs may have to be purchased.

If the second option, hosting with an ISP (or hosting company) is chosen, there are additional considerations. Hosting fees typically are based upon traffic to the website either in hits or in bits per month downloaded. Another consideration is the network load of the hosting company. In many cases, attractive rates for hosting camouflage oversold or mis-managed ISP backbone connections. Overbooking of the ISP's backbone can make the agribusiness' site unavailable or take an interminable length of time to load during heavy traffic periods regardless of the viewer's connection speed. Often, hosting companies purchase their bandwidth from an intermediate ISP (rather than an NSP), meaning that each hop to the Internet is a potential network bottleneck. However, directly hosting the site at a tier 1 carrier can be prohibitively expensive.

It is always good advice to visit the hosting company personally to see the server that will host the site and physically examine the surroundings. Another issue concerns the availability of technical support personnel during non-business hours. If the site goes down at 6:00 p.m. EST Friday, that could be a disaster for a firm counting on weekend West Coast or Asian viewers if no ISP help staff will be available until Monday morning.

Many hosting companies allow customers to use software packages and the rights to specialized serves such as shopping carts, e-commerce programming, RealAudio or RealVideo servers, and other specialized equipment the firm would have to purchase itself if it self hosted. Multimedia issues are discussed in more detail in 4.9.10 while 4.9.6 covers application and operating system issues. These technical details may not be available from all ISPs or prices may differ dramatically among those that do offer them. By using a hosting company, rural agribusinesses can avoid slow or non-existent high-speed infrastructures and avoid having their website traffic compete with the firm's own Internet traffic.

A third option is collocation (shown on the right side of Figure 4-57). Collocation involves placing (collocating) a purchased or rented web server dedicated completely to the business at the ISP's premises. Collocated servers have the advantage that certain connection charges can be avoided and they may offer greater speed when directly connected to the ISP's Internet pipe. Security can be improved when the server is kept in a locked cage at the ISP premises, but it is important that business personnel be able to access it on weekends or evenings in case of problems. Under many collocation schemes, the agribusiness is responsible for making sure the server remains operational and not the ISP which is responsible only for a cage, a connection, and electricity. Thus, it is also important to understand the emergency power supply and weather event policy of the ISP that will host the collocated server.

An agribusiness can choose Internet connections and e-mail service from an ISP not involved in hosting their website. However, there can be pricing advantages to using a single source. Policies regarding the number of e-mail accounts, amount of e-mails, spamming, etc. can vary by ISP. Some ISPs have been blacklisted for spamming so that e-mails sent by the firm might not be accepted at many destinations.

Pricing of website hosting will vary by which of the three options is chosen and according to the hosting company or ISP. There may be fixed costs of installation and for web servers, recurring charges for disk space on an ISP or host server, and recurring fixed or traffic sensitive charges (or both) depending on the ISP, NSP, or hosting company. Table 4-35 gives a quick summary.

The first part of Table 4-35 (best read in connection with Figure 4-57) shows that the self-hosting agribusiness may face higher costs in hosting its own site. First, by taking on the responsibility of hosting, it incurs webserver costs, server installation, firewall costs, and programming expenses.[41] Recurring programming services will be needed to maintain the operation of the site and to provide security.

Self-hosting requires a dedicated access connection (such as a T-1) to be obtained from a telco or other provider that is capable of carrying website traffic and Internet traffic from the agribusiness to the ISP POP. The agribusiness must pay an ISP to carry that traffic on to the Internet. If the agribusiness self-hosts, Internet access will include two kinds of traffic (website and agribusiness Internet) as it flows over the ISP backbone to the NAP to reach the Internet.

Some installation charges may apply and additional CPE may be required to support the dual traffic over the access connection that takes traffic from the agribusiness to the ISP's POP. The main advantage is greater control over the website and better security. There is a danger that web traffic could congest the access connection or the ISP's connection to the Internet so that both web traffic and ordinary agribusiness Internet traffic would be slowed. The ISP's flat-rate pricing for Internet access may be augmented by transfer charges for traffic above a certain number of megabytes per month when the agribusiness self-hosts.

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[41] The additional monetary costs of web design, programming, and maintenance are covered in 4.9.4.

Table 4-35: Pricing and costs for web hosting.

Method	Recurring	Upfront costs	Traffic-sensitive charges
Agribusiness hosts own site			
Self-hosted (direct expenses of agribusiness)	Programming, maintenance, security.	Web server, installation, firewall, programming	Possible upgrade if server is insufficient
Internet access connection (carries firm's Internet traffic, POP to CPE)	Monthly charge to telco	Installation, DCE (edge devices, routers)	Not usually.
Web site access connection (carries website traffic, POP to CPE)		Installation, DCE	Not usually.
ISP backbone (carries both website and firm's Internet traffic, POP to NAP)	Monthly charge to ISP	Installation	Possible extra charges if web traffic exceeds hit or MB limits.
Hosting company hosts site			
Host Co. or ISP (direct costs of ISP or host co.)	Hosting fee, value-added services.	Installation	Possible upgrade required if traffic too high.
Host backbone connection (carries website traffic, POP to NAP)	Monthly fee to hosting co.	Possible installation	Yes. Beware of "unlimited" offers.
Co-located server owned by agribusiness at ISP premises			
Co-located (shared expenses of agribusiness and ISP)	Co-location fee, bandwidth.	Server, programming to bring site up	Extra charges if traffic exceeds hits or MB limits.
ISP backbone connection (web site traffic, POP to NAP)	Monthly charge to ISP.	Installation	Possible extra charges if web traffic exceeds hit or MB limits. Beware of unlimited offers.
ISP backbone connection (agribusiness Internet traffic, POP to CPE)	Monthly charge to ISP.	Installation	Not usually

If a hosting company hosts the website, fewer maintenance or IT personnel charges are incurred. With a hosted site, the agribusiness does not have to have an Internet access connection of any kind. The host's POP to Internet NAP connection is the main cost. The agribusiness is charged a recurring hosting fee in combination with a rate on the actual data transfers made using the capacity of the connection from the hosting company to the Internet. Installation charges would be the main advanced costs. If web traffic exceeds the expected level, a service upgrade might be necessary. Some hosting companies offer unlimited web hosting for a fixed monthly rate, but in order to offer low rates such hosts may overbook the circuit from host to Internet NAP. Other unlimited access plans may be overpriced according to the traffic likely to be generated by a small website. One hosting plan does not fit all agribusinesses.

Finally, co-location strategies save the agribusiness the expense of increasing bandwidth between the ISP and the business location. The ISP and agribusiness share the expenses of setting up a dedicated server (owned by the agribusiness but located at the ISP). This allows the agribusiness to save the cost of back-hauling web traffic to its own location and possibly overwhelming the access connection used by office staff. The agribusiness pays the ISP for the ISP to NAP connection used for its ordinary Internet traffic together with traffic for the website itself. It would also pay a telco or wireless firm for a dedicated access connection from the agribusiness to the ISP's POP to serve office Internet demand.

The actual cost of hosting must be balanced against the benefit of increased control and access connection costs. An important advantage of co-location or using a hosting company is that the agribusiness' own infrastructure (if poor) is not at issue. The choice of a hosting company, reservation of IP addresses and domain names are only two ingredients in an agribusiness' Internet strategy. Next, website design and maintenance are considered.

4.9.4 Website Design, Programming, and Maintenance

Website design, programming, and maintenance are covered together to underscore the philosophy that a website is not an end in itself but an ongoing process. Because an agribusiness' web site is built in the dynamic realm of virtual space, it is unlike a magazine advertisement or new office building though it can function as both. However, unlike a static magazine ad or completed construction project, work on a website is never finished. This subsection discusses examples of what a website can do, the steps towards creating or updating one, and some pitfalls in design, along with guidelines for maintaining a website.

The WWW is a multimedia vehicle. Hence, websites can contain text, graphics, product photos, video, audio, interactive demonstrations and tutorials, frequently asked questions (FAQs), links to e-mail and telephone numbers, chat rooms, guest books, e-mail and fax auto-responders, and many other messages. The design of a website is best thought of as an ongoing process. Sites must be tailored and updated regularly to suit changing customer and agribusiness needs.

Readers are already familiar with many examples of the potential of websites for agribusinesses and non-agricultural businesses alike. Here are several examples of how websites and Internet use fit agribusiness needs. The B2B market is an especially hot area where farmers may purchase feed, seed, and equipment online. One example is the @gshop service from Progressive Farmer magazine's agriculture.com. Farmers are able to purchase supplies through a bid-asked process that is free of middlemen. Another example are pricebots, price shopping services that hunt through the Internet to find the lowest prices for inputs worldwide and allow buyer and seller to interact. Price alarm and warning services dispatch e-mails or even execute limit orders on forward and futures markets giving farmers and marketing firms the ability to react automatically to price changes.

Weather and GIS (Geographic Information System) monitoring sites can alter farmers to upcoming severe weather or frosts, highlight areas where hail damage has occurred, and even provide scientific advice concerning when to irrigate and summarize field scouting reports. E-commerce applications (touched on in more detail in 4.9.9) use web sites to fill and track consumer orders, schedule sales appointments, answer product questions, and provide interactive technical support. Clients can pay bills online and obtain account statements as well.

Another example of how web sites can be useful includes helping agribusinesses to reposition themselves, such as helping cattle ranches to earn income from guest ranch and hunting services. Industry groups benefit from being able to offer PR information about agriculture and use web sites to gather marketing and legislativ e information so it can be instantly communicated to members. Employee recruitment sites and the spotlighting of business community involvement and charity projects are also done on web sites. Auctioning and bartering sites are becoming particularly important in high-end breeding operations and for marketing feeder cattle. Real-time video inspections of orders to be shipped, international market expansion, gathering of market information, better access to extension bulletins, and solicitation of investors round out the list.

In short, websites serve many other needs in addition to direct sales, advertising, and communication. Due to the many possible uses, it is important for the agribusiness to develop a website sequentially. According to MindSpring, there are five steps to be followed in web site design and start up [Mind Spring, 1999]. These steps include picking a site strategy, designing your site, setting up your site, maintaining your site, and marketing your site. Of the five, the focus of the next passages will be on the first four strategies. Site marketing, which consists of promotion, measurement, and management, is covered next in 4.9.5.

The first step, choosing a site strategy, includes selecting both quantitative and qualitative goals for the web site. Some qualitative goals include polishing the corporate or industry image, disseminating product information, boosting employee morale, and improving customer service for existing customers. A website can be used to strive towards quantitative goals such as to make new customers, obtain new international or national sales prospects, create a retail storefront or e-agribusiness, and even provide demonstration software distribution. The site can also be used to distribute sales catalogs, to survey customers, and even to facilitate anonymous complaints. It is crucial to prioritize objectives according to their importance and implement decisions quickly. By creating a digital information library about products, creating 24-hour virtual employees, gathering instant market research, and establishing a retail storefront, Mind Spring argues that the web will "make life easier for you and your customers" [MindSpring, 1999, p.1]

The second step, web site design is another service that can be done in or out of house, depending on the needs of the agribusiness, staff abilities, and budget. One advantage of web sites is that they are relatively inexpensive forms of advertising and communication. Both advertising and communication are important because websites are a multi-faceted medium. First, the web is an advertising medium capable of sending customers and prospects advertising messages. Second, a web site functions as an interactive customer-centered medium to allow customers, suppliers, and prospective employees the ability to cheaply and instantly communicate with the agribusiness.

There are many web design pitfalls. Some have to do with the simple visual design of the page while others are related to more complicated programming issues for dynamic web sites. Before briefly discussing what to look for in a web designer and a web programmer, consider some common design and programming pitfalls. Then, it will be more apparent why the twin decisions of design and programming are often assigned to professionals outside the agribusiness.

Design also depends on the demographics of existing customers and new viewers. The diversity of viewers themselves and the diversity of their computers, video displays, browser versions, operating systems, and connections are extremely important. Some viewers may be dial-up customers with 28.8 modems running Windows 3.1, while others may be on a large corporate network using a Windows NT client and a T-3 connection. The audience may use non-IBM PC platforms such as Unix workstations or Apple Computers.

Graphics displays of viewer computers may range from 640x480 to 1600x1200 while color depths can range from 8 to 32 bits. Different web browsers from IE (Internet Explorer versions 3 to 5) to Netscape versions 2 to 4.7X (now also version 6) each perform somewhat differently. There can be dramatic differences in how well content displays if at all. Viewers from OSPs such as AOL or Prodigy, from wireless providers, or from WebTV frequently report they cannot see content or perform certain actions (such as launch forms or order). Foreign language viewers may have additional concerns, especially if their browsers are set to see content in a native alphabet that is significantly different from the Latin character set used by English.

While the idea of the Internet is to permit interconnection it is important to understand that a firm's web site will "look different" on one computer compared to another depending on graphics capabilities, operating systems, and browser versions. Furthermore, web page content will load slowly (or not at all) depending on the viewer's Internet connection. Even if both the viewer and the agribusiness' web site have high-speed connections, Internet congestion and routing hops can slow traffic to a crawl.

There can be requirements on the viewer's computer as well. If the web site collects orders or form data from customers using middleware, the viewer must have a compatible browser. Web sites with visual or audio content may require use of browser plug-ins such as Shockwave, Adobe PDF, or the Real Audio player. Viewers who do not have these programs will have to download them. Even though most plug-ins are free to download in an accounting sense, the economic costs can be significant in the time it takes to download them and install, especially for the sizable number of dial-up viewers.

Guidelines to make sites interesting enough to attract return visitors include informative and interactive content on an easily navigated site. Since presentation of a particular product is of necessity short on the index page viewers who want more detail should have the opportunity to link to explanatory text that provides more detail deeper in the site. Clean images (those at sixteen or thirty-two colors) take less bandwidth and make sites faster to load. Many web designers suggest that page requests (HTML files and images) be kept between 15kB and 40 kB so that

AOL dial-up visitors and others with slow connections[42] are able to view content. For example, viewers may not wait around over a minute to download a 250 kB photo. Recall that the file size on a directory is one-eighth the bits that will be transferred (250 KB x 8 = 2 Mb). Without taking into account error, overhead, congestion, and other factors, the fastest the download would occur is over thirty seconds. An increasing number of sites (such as weather.gov) offer viewers the choice of everything from simple text only to intricate multimedia content through selection links on the default page.

Setting up the site is the third of MindSpring's five steps. HTML design should be thoroughly tested with a variety of browser versions, operating systems, with AOL and WebTV, and on different graphics screens. Misspellings and non-working links should be taken care of as well before the site goes live. Even with a perfect HTML design, there are many web site programming pitfalls to avoid. Many agribusiness websites are already a mix of design and programming. As web site programming becomes increasingly important, it is important to consider some programming pitfalls to avoid.

Typically, programming problems surround the qualifications of the programmer, the use of web middleware, and the synergy with the characteristics of the visitor's machine. Middleware is defined as "a layer of software designed to sit between one system (usually a client) and another system (usually a server) and provides a way for those systems to exchange information or connect with one another even though they have different interfaces." [Sheldon, 1999, p. 622] Originally, web sites were written in HTML only and were essentially static documents, solely with design HTML elements. As the Internet grew in importance, specialized programming was needed to allow web pages to come alive with attention-getting features such as real-time clocks, newswires, and stock tickers. As e-commerce skyrockets, viewers needed to be able to order online and access dynamic databases such as sales information, availability, and other kinds of information.

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[42] Recall that over 53% of viewers have 28.8 kbps or slower connections per Figure 4-3 in 4.2.2.

CGI (Common Gateway Interface) was the first web middleware package designed to allow web servers to create dynamic documents such as personalized online order forms. Increasingly, web users needed access to data stored on back-end or mainframe machines and a better way to come up with information automatically than CGI which was slow and tended to overload the web servers. Now, a variety of "universal" database and other middleware packages are used instead of CGI and in addition to HTML. Some of the more familiar ones include Java, JavaScript, Microsoft ActiveX, and SQL (Structured Query Language).

For agribusinesses, middleware allows web users access to select information that is on mainframes and data servers in the private data network of the agribusiness. The web server runs a middleware package that can communicate with the agribusiness private computers and the viewer's browser to allow Internet visitors access to certain kinds of useful information without compromising security of the private data network. The necessity for middleware varies according to the type of business.

For example, a nursery can use middleware to showcase the plants it has available using plant pictures, prices, and other characteristics as fields in a database. Retail or wholesale customers may search by common name, scientific name, flower color, sun preference, or any other characteristic. As new plant varieties become available, instead of creating a new illustrated web page describing each plant, a picture and some characteristics of the plant are entered on a database form. Then, the plant is added to the database and the plant's image (along with accompanying information) is automatically seen by site visitors. As pricing, colors, or the stock available is changed on the nursery's private data network, it is automatically changed on the web site. If necessary, the database can display plant pricing and information one way for retail customers and another way to the wholesale trade.

Programming such sites can quickly become complex and expensive. The HTML design is a simple boilerplate or template so the content results from what has been entered into the database and how well it displays. Because sites using middleware are complicated, there are more chances for things to go wrong. In a worst case scenario, middleware (if not fully tested) can prevent the viewer from seeing the information desired or cause the entire e-business operation to stop. Poorly written JAVA applets can cause a viewer's browser to crash. If the database is improperly constructed, the wrong price may be charged or credit card authorization glitches may prevent all orders from being accepted online.

Pricing of web design and programming services varies considerably. It is extremely difficult to quantify what a web site entails. According to netb2b.com, median prices from web design and programming firms for full site development vary as shown in Table 4-36. The prices quoted depend on a standardized definition of what a small, medium, and large site is.

Table 4-36: Web site design and programming prices.

Price	Small site	Medium site	Large site
National high (9/99)	$300,000	$750,000	$1,800,000
Median (2000)	$113,500	$119,500	$608,000
National low (9/99)	$720	$2,160	$7,500
Median in college towns (10/99)	$15,000	$51,500	$125,000
Range in college towns (10/99)	$1,500-$25,000	$5,700-100,000	$57,400-500,000

Sources: Carmichael (1999a, 1999b, 2000).

The large dispersion of prices suggests at least two conclusions. First, some businesses are paying up to several hundred times what others do for what may appear to be roughly equivalent results. The buyer should be wary of possibly inflated pricing. However, at the same time, it can be difficult to judge whether results are equivalent because of the complexities involved in a working web site. The buyer should be wary of low pricing because it could mask a cookie cutter design, an untested site, or many other unpleasant possibilities.

However, there is no question from these results that agribusinesses should investigate at least five bidders for their web site project. It is noteworthy that pricing at web design and programming firms located in college towns is comparatively lower than for other areas. However, research into population density and web site pricing has concluded that there is insufficient evidence to support the hypothesis that "prices are substantially higher in large metropolitan areas than they are in small towns or rural areas" [Brenner, 1999]. Some projects are contracted to firms with programmers in Asia in an effort to save money.

A new site may be priced as a project (using total prices as above) or on an hourly basis. Nationally, hourly fees range from $75 an hour or less for basic HTML to over $200 per hour for middleware programming (database and Java/Shockwave) [Carmichael and Morrison, 2000]. Design shops that charge by the hour may be reticent to quote a total price to the agribusiness. Shops that quote a price may have escape clauses in the contract permitting substantial overrides. It is important to get everything down clearly in writing before work is started. As the project continues, expect to pay more if the site is added to by ideas from either end.

Because of the complexity of web design and programming most agribusinesses will use outside firms to create, program, and maintain websites. Even if personnel within the agribusiness are qualified, there is no guarantee that they will always remain on the payroll. However, it may make sense for agribusinesses that rely heavily on the Internet to keep as much of the programming function on the firm's payroll as possible due to security and copyright concerns. Web design and programming can be another thorny legal issue because some programmers and designers insist that they (rather than the business that pays for the web site project) own the code and design.

Selection of the right web designer or programmer is not always simple. Several guidelines should be kept in mind. First, there is no need to limit selections to designers or programmers in the immediate area since communications and work assignments may be done over the Internet. Second, it may be better to use a shop with several designers rather than a freelancer. However, a freelancer with a superior reputation may be able to charge less. Third, it is again stressed that estimates should be solicited from several designers or programmers. The range of prices shown in Table 4-36 is too great to allow this advice to go un-repeated. Developing a RFP (Request For Proposal) to be given to designers or programmers describing what is desired is a useful process that helps the agribusiness focus on what it hopes to accomplish from a web site.

Fourth, it is important to watch expenses carefully and remain involved as the work progresses. Full payment should be made only upon satisfactory and timely completion of the project. Many firms have faced unexpectedly slow design progress or have paid money without ever getting anything in return. It is extremely important to check working models of the site (or program) as work progresses using different browsers, computers, and connection speeds to see how well the system performs in action. There are many cases when the designer or programmer has insufficiently tested the site and the results have been catastrophic.

While agribusiness managers do not need to be Internet experts to use the technology, it is important to remember that communication is needed for sales to occur. Therefore, there are four communication-related characteristics for web sites that the agribusiness should insist upon. First, the site should have e-mail links to the agribusiness and those e-mails should be answered promptly. While the e-mail addresses used on the site will be harvested for addresses for spam lists, wading through junk e-mail is a small price to pay compared to not getting feedback and inquiries from viewers.

The second communication characteristic the site should have is to have contact information such as telephone and postal address on as many pages as possible. This can help assure customers that they are not dealing with a short-lived or backyard agribusiness[43] as well as providing them with other avenues of contact. Non-Internet contact information also tells customers where to call and order if they are uncomfortable with ordering online or if they have questions the web site does not answer about the product. Furthermore, a working telephone number and postal address are useful to allow viewers to report if the web site is not working or to inquire about what happened to an order they never received. Web pages should also have e-mail links (to the agribusiness, not the programmer or designer) that viewers may use to report problems with the web site.

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[43] If the agribusiness is new to business or is a side business run out of the home, some kind of postal and telephone information is even more necessary. A good web site can enhance the firm's image, but lack of an address or telephone number on the web site may not give some customers the reassurance they need to become a customer.

A third characteristic all sites should have is working links. Links on the site (and all content pages) should be re-tested regularly. Web sites may seem deceptively simple. While the freedom of possible actions a viewer may take is part of the allure of the WWW, when all the combinations and permutations are considered, the number of possible problems is staggering. Rather than having to be told about services and products the way the agribusiness chooses, customers can choose the order and level of detail based upon what information they want to know. However, the interactive approach can be unpredictable enough that the unexpected is likely to happen. A single misspelling of a link to a product or a failure to anticipate viewer responses to a form or shopping cart program can cause the customer to lose faith in the agribusiness. This is especially true if the ordering or information-getting processes do not work, take too long, or cause the viewer's computer to crash.

The fourth characteristic that agribusinesses should ensure includes a complete copy of the site and the right to use it even if the relationship with a designer, programmer, or ISP is severed. The copyright to the site, all hosting passwords, program code, and a full backup copy of the site (including HTML and graphics) should be obtained by the agribusiness. There have been cases where hosting servers have crashed without backups, completely erasing a site's contents forever. ISPs or hosting companies have also been known to erase sites of businesses that are delinquent in their accounts. If the agribusiness changes designers or programmers, it should not have to pay a new person or firm to reinvent the wheel.

Finally, during site set up and the early phases, agribusinesses should visit their site regularly. One way to achieve this is by suggesting that employees set it as the default page that their web browsers (at home and at work) automatically open to at the start of an Internet session. By taking this step, the agribusiness is likely to notice if the site does not come up at all on a particular day or if something is wrong. Browser plug-ins, middleware applications, links, and programming features should be monitored and tested regularly so the agribusiness gets the site it paid for. Indeed, frequently visiting the site during site setup sets the stage for the fourth step in the design process, maintenance.

Now that the first three steps of the web design process are outlined, it is time to introduce site maintenance. Maintenance is one of two steps[44] that are never finished because even when a web site project is "completed", the agribusiness should not consider the site done. New content, additions, deletions, and regular maintenance are as important as initial design and testing because the web site is visible to viewers worldwide. Unless web sites are maintained regularly, content can become stale and outdated, creating a poor image of the agribusiness to viewers.

Often, the lack of maintenance does not result in anything more than embarrassment. However, not changing information can even be expensive as one poinsettia grower found in 1999 when customers demanded the lower 1997 Christmas special prices that had been left on its web site completed two years earlier. This kind of situation (where an agribusiness does not change the site at all after creation) obviously discourages people from checking the web site to see what is new with the company, defeating the purpose of cyber communications.

Storing and managing the voluminous material that can end up appearing on an agribusiness' website is the job of web maintenance (or web site management), another make or buy decision. Whether done exclusively in-house, exclusively by designers, or through a mix, web maintenance has both an art and a computer science perspective. The computer science perspective views a site as revisable, dynamic source data that requires considerable skill and troubleshooting effort to display flawlessly in fulfillment of the dynamic responsibilities placed on the web site, and not as final-form output. The art perspective views a site as a regular creative assignment with shifting technological and ever-expanding business objectives, and not as a completed work. These perspectives tend to annoy agribusiness managers (and their accountants) because both the designer and the programmer may sometimes seem to operate without limits and do not seem bound by any final deadline. Outside designers and programmers may do their best work if kept on a conditional retainer, where each month a set of tasks is to be accomplished for a particular sum before a particular date. That posture seems better than the open-ended retainer approach where both parties get around to maintenance when they feel like it.

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[44] The other is web site promotion, to be covered next.

If maintenance is done inside the firm, the web site must be managed in such a way that individual creativity and departmental initiative do not give way to total chaos or redundancy. A common approach (and one that can be very fruitful) is to have various departments and individuals have their own sections of the website while reporting to an in-house ombudsman. This tactic can get everyone involved in improving the site and making it useful to customers while keeping the look uniform and avoiding divisive themes. There may be no reason to hire an outsider simply to change prices, post monthly specials, or add e-commerce data to middleware.

However, according to Seybold, "treating web sites as persistent data stores introduces a new set of complexities in document management." [Seybold, 1996] Some organizations allow many departments or individuals to add to the firm's web site. It is easy for each department to create and update its own web pages using many differing goals, a variety of creative and computer science approaches and different software packages. If too many different people or departments put their own mark on the website without a central policy and a single watchdog, the result can be redundant source files, incompatibilities, and other problems. It is hard to track file and graphics revisions that are made in at least two locations, by more than one person, with more than one objective. In-house maintenance is possible using numerous software packages that are available to help non-designers and non-programmers keep content current. However, some of these (Microsoft Front Page is an example) require special web hosting arrangements and may become unstable when used with other web editing software packages, even causing the site to become invisible.

One of the benefits of using the WWW is that it is possible to track and measure what works (and what does not) using a variety of measurement tools. This subject and the related topic of promoting the web site so that many visitors see the site and return to it frequently are covered next. However, visitors tend to favor well-designed, well-maintained sites so promotion efforts are most fruitful with a well-designed, well-maintained site.

4.9.5 Website Promotion and Measurement

A well-designed website (even if hosted by a well-managed ISP with plenty of bandwidth) is of little use if no one visits it. Experts suggest that the site be targeted towards existing customers as well as new prospects for maximum success. Web measurement and web promotion are important tools that help agribusinesses tell if their efforts are successful or not.

Web measurement is a unique feature of the Internet. Typically, visits to a web site are automatically (and precisely) recorded in a log file. Statistical reports are available free from the hosting company (or for the price of an inexpensive software package) to answer who visited the site, when, which parts, from where, how long, and how often. The main units available include gross visits, unduplicated or net visits (uniques), page requests, hits, and bytes. These units can be cross-tabulated by time-of-day, date, month, and a host of categories that give characteristics of e visitors and visits. It is also possible to tell the order a visitor goes through the site, how long is spent per page, and many other details of a visit.

A page request occurs whenever a particular HTML page is accessed, while a hit occurs whenever any kind of file is accessed. For example if an HTML page has three images, a total of four hits would be recorded every time that HTML page is accessed. It is more difficult to count visitors since the log can only identify visitors by IP address. For level four and higher Internet access, IP addresses are typically assigned to a particular machine. When a person sitting on that machine requests the same web page twice, it is counted as two gross visits but only one net visit. These kinds of connections are typically associated with office Internet viewing or high-speed residential access such as via cable modem or DSL. However, the majority of visitors to a web site cannot be identified with a particular machine since dynamic IP addresses are assigned them. Hence, data about visitors is categorical[45], but data about visits can be specific.

Nonetheless, visitors can be classified according to their country, operating system, browser version, and graphics display capability. In this way, the agribusiness is able to gauge who is visiting the web site and how well their content is seen. It is possible to identify and classify viewers by TLD (.gov, .com, .edu, etc.) and by common domain names such as aol.com. Log data can even be used to tell whether competitors are visiting a site, as was the case during the 2000 GOP Presidential race. When visits to Sen. John McCain's campaign web site from rival George W. Bush's domain were among the top 10 traffic generators, the McCain camp knew its web site was being heavily analyzed by the opposition. Logs were able to tell what parts of the site were attracting the most attention so that competitive responses (and a press release) were ready. Log analysis is especially useful for security purposes because it can show whether attempts are being made to access directories or files that are meant for subscribers, employees, or are otherwise un-linked to the main site. Another reason log analysis is important comes from its ability to measure web promotion, the next topic.

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[45] Through the use of cookies and web advertising services such as www.doubleclick.com, viewing-profiles associated with a particular machine may be maintained. This topic gets more treatment in 4.9.8 under privacy and use policies.

Web promotion refers to the promotion of the site to existing customers, search engines, newsgroups, link exchanges, and the formation of associations with receptive organizations. Table 4-37 highlights fifteen steps that can be used to promote a web site. Promotion is another make or buy decision for the agribusiness. However, whether the firm self-promotes or hires a web site promoter, following these steps can pay off. Depending on the nature of an agribusiness, some of these may be more important than others.

The first step has already been mentioned in 4.9.3 when domain names were discussed, but it bears repeating. Agribusinesses should choose at least one domain name that contains a description of what the business does, sells, or services. Recall that more than one domain name can be programmed to point to a particular web site. Many agribusinesses have already taken advantage of descriptive domain names for two specific promotion reasons. First, it is easier for customers to remember nursery.com and to type it in their browser's location field than baileynurseriesofminnesota.com. Secondly, if one of the keywords to be associated with the business is also the domain name, search engines are likely to rank the site higher.

Keywords are words that are likely to be associated with the business when customers try to search for it. More will be mentioned about keyword promotion in step four. However, keywords that could be used as domain names include categories such as those in classified directories, brand names the firm has the right to use, product benefits, geographic terms, or any characteristic in the public's mind. Even if the "good names" already seem to be taken, new kinds of TLD (Top Level Domains) and geographic names are available for registration as detailed in Table 4-34 in 4.9.3. It makes always makes sense to register the names the agribusiness does business under as domain names even when keyword domains are used. That way, someone who knows the business name can find the website.

Table 4-37: Steps to promoting retail and wholesale business web sites.

Step	Description	Comments
1	Choose at least one domain name that contains the topic of your business.	Sellers of commodities can own the commodity name in cyber space.
2	Avoid ~ sites or free web sites such as GeoCities.	Some search engines miss these sites, customers are distracted by ads and pop-ups.
3	Make the welcome (index) page exciting to both visitors and search engines.	There can be a tradeoff between visually exciting frames and Java tricks and appealing to search engines through English.
4	Insert well thought-out HTML titles, descriptions, and meta tags (keywords).	Be brief while avoiding simple keywords and trite descriptions.
5	While avoiding outright spamming, post short non-commercial sounding responses to *topical* Usenet newsgroups, and commercial networks of AOL, etc.	The more technical the product, the more likely there is someone seeking help. Provide it while promoting your company.
6	Send out cyber press releases through an automated service.	Avoid overusing. Press releases are for news.
7	Build the web site and the top keywords into registered sub-URLs.	Can be very important for businesses selling multiple commodities.
8	Have an outside link page and cultivate link exchanges with trade groups, government, educational, and other sites.	Extremely important.
9	Register and re-register with as many search engines and directory indexes as possible. Make sure to include foreign, local, specialized, and new engines as applicable.	Listings grow stale, have long lag times, and need specialization.
10	Avoid constantly changing page names.	Search indices have built-in lags. A deleted page name can be a missed visit.
11	Make sure web address (and e-mail) appears on business cards, letterhead, boxes, delivery trucks, bags, voice mail, and in all ads and industry listings.	Customers need reminding that they can visit whether the office is open or not, whether the telephone is busy or not, etc.
12	Realize that Internet viewers are looking for information, communication, entertainment, and education in addition to a place to shop or to get product information.	Avoid pure sales pitches.
13	Do not hesitate to feature employee photos or to spotlight news and accomplishments from around the firm.	Employees and their families are surprisingly good at promoting sites where they are featured.
14	If international orders are wanted, go out of the way to welcome and cultivate foreign visitors.	Page translations, promotion to foreign search engines and fast-loading graphics are useful.
15	Use measurement tools to see what works.	Web specials and coupons can be used to get cash register measurements.

Adapted from Fairchild (1998).

The second step in promotion is accomplished if the first step has been. However, the lure of a "free" web site may cause small agribusinesses to ignore step two. Ignoring step two also prevents others steps (especially seven and nine) from being taken. If the agribusiness uses a website hosted by a free hosting site such as geocities.com or hosts via a dial-up account under an ISP domain such as www.isp.net/~username it is asking for trouble. Some search engines entirely miss such sites. Furthermore, the URL's are hard to remember. For example, sites on GeoCities may require up to twenty characters with several slashes in the right places. Free web hosting companies make money by selling advertising pop-up windows and banner ads that compete with the content of a hosted site.

The third step seems obvious: make the welcome (index.html) page exciting. However, the index page must be exciting both to human viewers and to search engine robots (or bots) which are spider programs that browse up to thousands of sites an hour. many viewers enjoy eye-catching graphics, traveling tickers, contests, short animation or graphics (provided they can be downloaded over a dial-up connection), contests, interesting backgrounds, etc. However, adding too many bells and whistles may cause the substance to get lost in the style, increase download times, force viewers to download plug-ins they don't want, annoy them with time-consuming commercials, or even cause their browser to crash.

Meanwhile, there is a tradeoff between content that humans find exciting and content that leads to better search engine rankings. Visually exciting frames, involved Java applets, and automatic database windows may be attractive to humans, but they are virtually invisible to search engines. Search engines look for the same keywords their customers do in web pages so that text seems to be most exciting to them. Promotion to search directories such as Yahoo! (where a human visits every site before it can be listed) can be difficult. However, these directories are among the most popular and making the site more attractive to human editors can be an important source of traffic. To fulfill requirements, it is necessary to have information-rich text using keywords in context, interesting links, and content that furthers knowledge in general.

These tactics also encourage viewers to stay connected and bring them further into the site. A professional web promoter may be of real help with improving site rankings with the most popular engines (which can be responsible for over 90% of new visitors).

The fourth step is to have well thought-out titles, descriptions, and keywords (meta tags) on the index page and other pages within the site. Only the title will be visible to viewers and if they should decide to bookmark an agribusiness' page (in Netscape) or choose it as a favorite (in Internet Explorer) the title will be what they click on to return. Titles should be descriptive of page content with some keywords peppered in. However, titles with too many keywords or over a certain number of characters risk being seen as an attempt to spam search engines.

Search engine spamming (the deliberate attempt to trick viewers into visiting a site by listing unrelated keywords or too many of them) makes fruitful searches hard for search engine customers. Many engines are programmed to reject sites that spam and the names of the worst offenders may even be blacklisted among engines. Spamming is most likely to be attempted in the parts of an HTML document not seen by the viewer, the so-called meta-tags. Meta-tags typically include two fields on the web page, the description field and the keyword field. A few complete sentences of copy using the most important keywords (and describing what is on the site) are used in the description field.

The keyword field should contain at most fifty to one hundred keywords (single words or word combinations) that are most likely to be used in finding the site. The agribusiness or web promotion consultant should draw up a keyword list that contains specific descriptive terms along with common misspellings of keywords, geographic locations, brands, sizes, etc. The success of establishing keywords for an agribusiness site depends heavily on who else is trying to use the same keywords. The keyword "stud service" is likely to be far less effective than keywords such as "lychee" or "carambola" because there is less competition (within agriculture and outside of it) for use of the words.

Often, it may appear that using widely used terms such as orange juice are hopeless. However, modifiers and alternative forms such as "wholesale Florida orange juice concentrate" or specific trade terms such as "reconstituted Florida orange juice, Brix-acid ratio 13:1" could work as keywords or in meta-tag descriptions for a juice processor. Such keywords might be closer to the terminology a professional buyer would use instead of typing in "orange juice" alone and getting tens of thousands of results. Remember that it is necessary to consider the target searcher-viewer. If a site hopes to attract local retail customers, the keywords used will differ from those that would be used to attract technically oriented or wholesale buyers.

The next two steps require caution. Step five involves the posting of short, non-commercial sounding responses to topical discussion threads on Usenet newsgroups along with AOL and other commercial discussion groups. This involves posting a public e-mail to a discussion thread (the subject of an earlier posting) that will be seen by people interested in a particular subject enough that they have subscribed to a particular newsgroup. Caution is required. A blatantly commercial message will be seen as newsgroup spamming and may be ignored or become the subject of public flames (attacks against the poster in the newsgroup) or private flames where the e-mail address is flooded.

The agribusiness should only use this method of promoting its website if it can give advice or counsel to people who have put out threads looking for information in an area topical to the business. For example, subscribers to the newsgroup alt.agriculture.beef might welcome responses to specific questions about cattle breeding from a qualified breeding operation, even if the posting included a link to the firm's web address, etc. However, members of the newsgroup soc.tahitian.dancing (if there were any) might resent an invitation to visit the breeding operation's website, especially if the invitation was also sent to 2,000 other newsgroups. Newsgroup postings can be an excellent way for an agribusiness to get its name on the cyber map, but someone in the firm must read the newsgroup, compose the messages, etc. Furthermore, any e-mail address used to post on a newsgroup can be captured by spam list harvesting programs and may end up getting spam e-mail.

Cyber press releases can be sent out to promote sites through special automated services. This promotion option may be useful for agribusinesses when they open a new site, go online with e-commerce, or have some other newsworthy item to report about their site. It is important not to overuse this option since the trade press can only use items that have some news value.

The seventh step is closely related to the first and the fourth: build the web site and top keywords into sub-URLs. ADM has some domain names that would serve as examples. Sites such as admfeed.com, and admgrain.com, could be separately promoted and routed to the main web site admworld.com. However, an agribusiness does not need ADM's budget to use this promotion policy. Domain names are less than $50 per year and often can often be pointed to the index page of a website on another already hosted domain for no charge or a minimal set up fee by the ISP. The traffic that results can be substantial. Another related tactic is to promote different pages under the same domain. For example, a cattle breeder could promote its index.html page, its angus.html page, and its hereford.html page separately to the same search engines. Traffic would enter the website at the promoted page, but if pages were designed appropriately, there is no reason the index.html page has to be the main page. The multiple page approach does not work with all search engines.

Step eight, having an outside link page and cultivating link exchanges with trade groups, educational, government, and other commercial sites can be extremely important to building traffic. An agribusiness in Lee county might be able to get listed on Lee County Chamber of Commerce or other association sites, on the sites of organizations of which it is a member, and even on a local government site. Government and educational institutions can sometimes link to commercial sites if the site has great informational and educational value or has its own link page that lists sites in a particular industry or science. Vendors, neighboring businesses, and sites owned by people with personal relationships to the agribusiness may link to the site, especially when a reciprocal link is provided. This option can also be time consuming and require much e-mail to get link exchanges going.

Step nine concerns the logistics of registering with search engines. Generally, it makes sense to register (and re-register every few months) with as many search engines as possible. Foreign and specialty engines should be included where applicable. Re-registration can be important because search engine listings grow stale once competitors for particular keywords (in the industry or out) register keywords. Other sites may become ranked ahead of an agribusiness that registers first and fails to promote on an ongoing basis. The main goal of search engine registration is for the site to rank near the top when the keywords are used by searchers. Many customers will only visit the first few sites on a search list that can contain hundreds or thousands of names.

Search engine registration is not the only reason that step ten (avoid constantly changing page names) is included. If viewers have bookmarked a particular web page on a site, they may not spend time hunting for it if a "file not found" error greets them on their next visit because someone decided to change page names or directories. If changes in domain names or directories are important, the old URL should redirect viewers to the new one. Search engines have built in lags and even if the structure of a web site has been changed, the new structure may not show up for months (if at all).

Step eleven might be the most obvious. One often-forgotten purpose of an existing web site is to serve existing customers. Hence, an excellent way to promote a site is to tie it in with existing marketing efforts. The site can be mentioned along with e-mail addresses on all company literature, advertisements, Yellow Page ads, business cards, sales material, delivery trucks, in-store signage, packaging, and other collateral material. For businesses with automatic telephone answering (during or after office hours), it is a good idea to mention the web address if the answers to many common questions (hours, prices, product availability, specials, etc.) are available online. This helps customers find information when the business is closed or telephones are busy, especially if they have routine questions about hours, location, or acceptance of charge cards.

The twelfth step is advice on content. The Internet is not a purely advertising medium; it is also a communications medium. Since viewers are looking for information, entertainment, education and advice they may shy away from sites that amount to pure sales pitches. Search engines know that viewers prefer sites with the keywords they searched. Furthermore, commercial sites can inform about what a product does, how it is made, why it helps customers how much it costs, what terms of delivery and credit are, how it can be used, who else uses it, etc. An excellent feature of HTML is that content can be layered in successively greater levels of detail when and if an individual viewer seeks detail. For instance, detailed engineering blueprints or owner's manuals are usually several clicks inside a website since such technical details download slowly and are not sought by everyone.

Pricing information on the site can be a cagey issue, especially for wholesalers or retailer-wholesalers. If the agribusiness is eager to promote low prices, special discounts, easy credit terms, or other features it can do so within page titles and keywords. However, the format of a display or classified newspaper ad may not work unless used as a link to web specials, etc. Wholesale firms may decide to layer their site so that price information is available to subscribers with passwords. Whether password protected or not, special codes can be used so that search engines do not index pages with proprietary information or trade pricing. However, if retail or wholesale customers are "price shoppers" the agribusiness may prefer to promote price-related content.

The thirteenth step can be particularly useful to promote the site to small town sites or to specialized online communities. Featuring employee photos, spotlighting news and accomplishments around the firm, and using the site to promote employees as well as the company is good for morale and good for business because it converts employees into web promoters as well. Employees become more familiar with the web site when their pictures are displayed (individually or as a group). Furthermore, employees may promote the site by pointing it out to friends, neighbors, relatives, and other potential customers. Some firms even pay commissions to employees whose promotion efforts result in sales. Such programs require guidelines to avoid abuse and cross-purposes.

Next, if international viewers and customers are desired, go out of the way to welcome and cultivate them. There are many ways of doing this, beginning with promotion to foreign search engines. Free web page translations can be obtained on the Internet so that single welcome pages in foreign languages (such as italiano.html, espanol.html, and francais.html) may be put on the site in these languages. The purpose of these welcome pages is only to greet visitors in their own language and as the page to be promoted to search engines in that language, not to translate the entire site. From the foreign language welcome page, international visitors click to pages they are interested in (written in English), that may be translated using special links. The agribusiness has to be careful since automatic translation may offend rather than communicate. It is best to have someone who understands the language read the page and make sure the translation is accurate. Some agribusinesses with a shortage of multilingual employees have found that translating an entire site or parts of it into another language can pay for itself. While many customers may be able to order and carry out business in English, they may purchase more often and more frequently if web pages in their native tongue are available to help them get information about products and services.

Even without special web pages targeted to foreign prospects, many agribusinesses have become importers and exporters without having intended to. It is likely that most foreign orders will be for hard goods, non-perishable foods, or services rather than perishable products. Shipping charges and arrangements, duties, taxes, export regulations, and import laws in the country where the customer is located can vary dramatically. In addition to finding out about shipping charges, it is important to check with customs brokers and foreign consulates about rules specific to the country to be exported to. More information is available from freight forwarders or the federal government through the Department of Commerce's site, www.ita,doc.gov or the Export Control Administration's web site www.bxa.doc.gov.

The last step shown in Table 4-37 encourages the use of measurement tools (mentioned earlier in this section) to see what works. If the tools are used, visits to a particular page or referrals from a link or search engine listing can be measured to observe which step or steps are bringing the most traffic. Promotion efforts can then be tailored accordingly.

The job of web promotion can become a complicated one, particularly if the agribusiness places great hope on using a web site to attract new business. Web promotion firms and freelancers are available for hourly retainers or for project-based fees to do some or all of the work. If an outside promoter is hired, work has to be coordinated with the individuals responsible for web design and programming because web promotion involves changing meta tags and titles in individual web pages.

4.9.6 OS & IP Applications and Services

Like other computers, web hosts and Internet servers located at agribusinesses have operating systems as well. Depending on the operating system and the web server software that operates on top of the OS, agribusinesses may be able to use specific applications or TCP/IP utilities as part of their Internet access, web hosting service, or both. Recall from Figure 4-57 (in 4.9.3) that the agribusiness may separate Internet access from web site hosting. Hence, OS and IP applications can apply to either the web site equipment or the firm's own Internet access equipment or to both. Such equipment may be owned by the agribusiness and located at its own premises, owned by the agribusiness and co-located at an ISP or NSP premises, or owned by the ISP and shared with up to thousands of other users. Therefore, it is difficult to be specific because much depends on the particular design of network architecture. Beyond the access connection itself, there are three variables factors that affect what is available on an Internet server (whether a web server, an office host, or a combination of the two).

Server hardware is the first variable. Servers are network computers that provide services to users (the topic of this sub-section). The type of server is one important indicator of the services that can be provided. The web server can be a microcomputer such as a Pentium-powered IBM-compatible multiprocessor server, a mainframe or minicomputer server, or a superserver [Sheldon, 1999]. Pentium-based servers are the least expensive, but also are able to handle fewer simultaneous instructions from users.

Software, including the Operating System (OS) and the server software that runs on top of the OS is the next variable. While all computers use TCP/IP to communicate over the Internet, an OS (operating system) designed to work with specific hardware is also necessary. Common network OSs include Windows NT, Windows 2000, and UNIX-based OSs such as Linux, Digital UNIX, Solaris, and FreeBSD. Specialized server software sits on top of the OS as well. For example, Apache runs on top of UNIX, while Microsoft Internet Information Server IIS) runs on NT or Windows 2000.

Ironically, the more expensive the server, the less expensive server software is likely to be. This is since PC server software tends to be proprietary and sold in separate modules, while mainframe software may be open-source and available for less than $100. The higher-level languages require specialized programming that can be precisely tailored to the agribusiness' needs. While out-of-the-box software needs far less programming, it can be more time-consuming to maintain and fail to offer desired features. For example, inexpensive Pentium servers may use Windows NT as networking software, but require IIS for specialized Internet applications and the purchase of Windows Exchange Server for E-mail. More expensive mainframe computers may be able to use a single non-commercial higher-level language to support all TCP/IP applications and utilities without buying specialized modules.

The cost of operation can be a wash when the two are compared. Programmers that write high-level UNIX code tend to be well paid, while proprietary software tends to have reliability problems such as the BSOD (Blue Screen of Death) that Microsoft Windows and NT users and network administrators are intimately familiar with. Once the higher-level programming code has been written, UNIX-based systems tend to be reliable so that costs are mainly fixed, based on programmer time spent initializing and debugging the system. With many kinds of proprietary software, there is a high cost for the initial software purchase. This direct cost is often followed by even higher costs for network administrators and IT staff to fix mysterious glitches, add new software packages without affecting the network negatively, and respond to reoccurring crises [Kirch, 2000].

While all the server software and operating systems mentioned support some TCP/IP applications, there can be enormous variations in what is available to a particular agribusiness based on OS, server software, security concerns, and the policies of their ISP. Table 4-38 shows common and less common applications in the IP suite. The most commonly supported applications (by ISPs, OS, and server software) are at the top of the table, with less commonly supported ones below them.

The first three items are generally available to agribusinesses with Internet access. The WWW and DNS are closely related. If the primary DNS goes down, a secondary DNS is usually available. DNS problems can result in the inability of all web sites to come up in a WWW session, the inability of some sites, or for the agribusiness' own site coming up. FTP access to an agribusiness' site may incur additional charges or be impossible for web sites hosted by a hosting company.

The next three entries are related to e-mail. E-mail options generally include SMTP for sending e-mail and POP3 for receiving it. Some ISPs and server software also supports IMAP as an e-mail protocol. IMAP is ideal for users who move around from machine to machine because the mail is kept on a stationary server. Mail that is received may be kept on a POP server if the user chooses that as an option. However, many ISPs and corporate servers discourage that practice because users leave all their e-mail on the server, causing disk space to be taken up. A copy of mail that is sent stays on the sending machine with POP so machines in the home office do not have archives of what was sent out on a home or branch office machine. IMAP also allows users to share mailboxes, making collaborative e-mail possible.

Table 4-38: Common and less common applications and utilities in the IP suite.

Acronym	Translation	Use
WWW, DNS	World Wide Web, Domain Name System server	Surf the Internet, convert web page addresses to IP addresses.
FTP	File Transfer Protocol	Exchange files.
Telnet	Coined	User communication (text only) to remote computer.
SMTP	Simple Mail Transfer Protocol	Send e-mail
POP3	Post-Office Protocol, v.3	Receive private e-mail on local machine.
IMAP	Internet Message Access Protocol	Receive e-mail continuously at multiple locations or on multiple machines. Mail stays on server can be used collaboratively.
NNTP	Network News Transport Protocol	USENET newsgroups (discussion groups).
ping	Packet Internet Groper. Uses ICMP (Internet Control Message Protocol)	See if another host is reachable from a machine.
traceroute	Trace the route a packet takes over the Internet from one point to another.	Troubleshoot connection problems.
whois	Who is the owner of a domain name?	Check availability of a domain name or obtain information about currently registered domains.
SNMP	Simple Network Management Protocol	Collect information on all devices on network for management.
IRC	Internet Relay Chat	Chat with other users.
SLIP, PPP, PPP Multi-link	Serial Line Internet Protocol, Point-to-Point Protocol.	Allow computers connected by modem or other methods to function at OSI network layer.
Access log	File containing IP addresses and other information about website viewers	Web measurement source data.
Shell access	Direct access to directory shell of server.	Ability to run programs and scripting modules directly on the server using server software and OS from terminal (another machine).
LDAP server	Lightweight Directory Access Protocol	Allow roaming access to e-mail, bookmark, and other web settings for users on the go.

NNTP is the protocol that supports news servers for USENET mail discussion groups (discussed in 4.9.5). Because USENET groups require transfer of an enormous amount of information, some ISPs and corporate networks do not offer news as a service at all, or it may come at a premium price.

Ping, traceroute, and whois are command line executions that help users to see if a particular machine is reachable from another, troubleshoot connection problems, and find out information about a particular domain name's owner. These three are technically applications and not protocols, but may not be available with certain OSs, difficult to run (as in Windows where users must find a DOS prompt), or forbidden under certain security conditions. However, outgoing whois, ping, and traceroute utilities may be accessed via special webpages if they are unavailable.

SNMP collects information on all devices on a network for management purposes. Depending on hosting and Internet access options used by the agribusiness this valuable tool may be unavailable according to ISP policy. IRC (Internet Relay Chat) is a method where users can chat on special channels (topical areas similar to newsgroup subject lists). IRC may be unavailable through some ISPs or with some OSs due to security concerns. Typically, IRC is not a business application and one-on-one messaging services such as AOL Instant Messenger are more powerful, more secure, and free.

SLIP and PPP are physical and data link layer protocols used to allow machines to connect to a network as a node via modem or to connect nodes or routers. Depending on equipment, ISP hosting software, and OS these connection protocols may or may not be available. Since transporting IP packets is an OSI network layer activity, SLIP and PPP are ways of allowing remote nodes higher connectivity. PPP provides a more robust link than SLIP, as well as supporting other protocols such as IPX (Internet Packet Exchange), a proprietary Novell product. PPP Multi-link allows channel bonding or the ability to connect multiple links between systems on demand. Recall from the discussion in 4.9.3 that DHCP servers, proxy servers, and Internet access levels may be set up in a particular way by the ISP or server OS.

Continuing with the listings in Table 4-38, the access log is the next entry. The access log on a web server is saved in various ways (if at all) depending on the OS or web server software. If measurement and site statistics are important, it is important to find out beforehand how a hosting company, ISP, or web server manufacturer sets up the access log of viewers to the web site. Shell access refers to the ability of users to access the UNIX shell or other OS shell or operating system prompt. Users with shell access can run programs and scripts on web or network servers without using their local machine's processing capacity or software. Shell access is not allowed by many ISPs because it can represent a security threat, but if it is offered (possibly for a premium), the agribusiness would have the computing power and program library of a very powerful machine available. Finally, LDAP access refers to a specialized directory services specification of the IETF that allows an organization to have a "white-pages" style e-mail and telephone directory and provide roaming access to e-mail.

Table 4-38 is by no means an exhaustive listing of the Internet Protocol suite and related applications. Availability of each item can depend on how (and from whom) the firm obtains Internet access and web site hosting. If both functions are at the agribusiness premises (level four or higher Internet access and self-hosted website) the agribusiness will have the responsibility and control over some of the lesser-known parts of the IP protocol suite. However, the usefulness of IP to an organization does not end with OS applications and Internet utilities. It is now possible for an agribusiness to avoid the cost of expensive dedicated connections, complicated "value-added" data networking services, and expensive enhanced telecommunication services to use the Internet as the carrier for its own secure private data network.

4.9.7 VPNs and Convergent Applications

Virtual Private Networks (or VPNs) can be used by the agribusiness as a low cost and secure way to connect offices, home offices, traveling salespeople, and dealers or vendors in a unified voice and data network. Some VPNs are mainly private data networks that use the

Internet as an inexpensive way to link computers together for fixed, nomadic, and mobile users. Other VPNs are true hypercommunication networks that offer full voice and data networking links among users of a firm's network, along with allowing communication with PSTN or Internet users off the network.

VPN is a confused term. However, as Sheldon says, " . . . the confusion has more to do with what to call VPNs as they evolve into new networking technologies." [Sheldon, 1999, p. 1051] Dramatic decreases in costs provide the incentive for appropriately sized agribusinesses to learn more about VPNs. For example, *Data Communications* magazine found in 1997 that annual communications costs for a three-city leased-lines network (dedicated circuits) were $133 thousand, $90 thousand for a frame relay VPN, and $38 thousand for an Internet VPN. First-year costs (including installation and specialized VPN encrypting devices) were $136 thousand, $111 thousand, and $54 thousand respectively [Cray, 1997, p.49]. For much larger firms (over 4,000 remote users), with annual data network costs of $6.2 million, Ascend found that a data VPN could reduce expenditures to $3.4 million [Ascend, 1998]. However, savings associated with VPNs can be obliterated by the costs of deploying software to SOHO sites, configuring those sites, and other hidden up-front and operational costs [Salamone, 1999]

Figures 4-58 through 4-60 shows several stages of VPNs. Figure 4-58 shows the pre-VPN communications configuration for a Florida agribusiness with a headquarters location in Homestead, three in-state branch locations, along with SOHO and traveling users. SOHO (Small Office Home Office) users may include executives, managers, and key IT personnel who work frequently (or mainly) from home, along with salespeople and other users who frequently travel nationally or internationally. These users currently use long-distance voice POTS lines to dial-into the firm's private data network at HQ or a branch office. SOHO users may enter orders, check e-mail, use the intranet, or use database or other applications on the company network that have been judged as too much of a security risk to do over Internet connections [Koehler, *et al.*, 1998]

Many agribusinesses may have dealers, wholesalers, or jobbers who sell their product and use dial-up access to communicate data with the agribusiness. In other cases, the agribusiness needs to use dial-up access to communicate with vendors to reach a vendor's secure private data networks or provide vendor access to the agribusiness' secure data network. One example is the Federal Express system where clients get a computer (owned by FedEx) and use 800 or long-distance dial-up connections (often charged by the minute) to check the status of shipments, etc. Many large retailers (home stores, department stores, and grocery chains) have similar systems their agribusiness suppliers must use in order to be paid promptly or receive discounts.

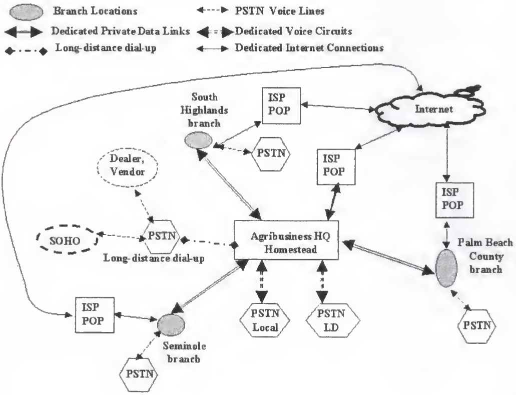

Figure 4-58: Before VPN: expensive long-distance dial-ups and leased dedicated connections.

A VPN such as the one shown in Figure 4-59 gets rid of expensive dial-up long-distance connections between SOHO or remote users and the home office without sacrificing security. Note that such users have gained Internet service (used to support the data VPN) in Figure 4-59. Whether SOHO users get dial-up or dedicated Internet access (and the capacity of the connection)
]

will depend on a cost-benefit analysis. The dealer-vendors have also gained Internet connections, so the agribusiness' Extranet for its own customers and vendors will be properly linked or so that customer or vendor Extranets may include the agribusiness.

Note that Figure 4-59 shows that (in addition to shedding the expensive long-distance dial-up connections), extremely expensive dedicated data circuits have also become unnecessary. In addition, the long-distance dedicated voice circuit (to the long -distance carrier's POP) has been replaced by IP telephony off the ISP POP. Making these changes can result in enormous savings. The dedicated data circuits among offices are particularly expensive for the agribusiness shown since they cross LATA (Figures 4-37 and 4-38) lines.

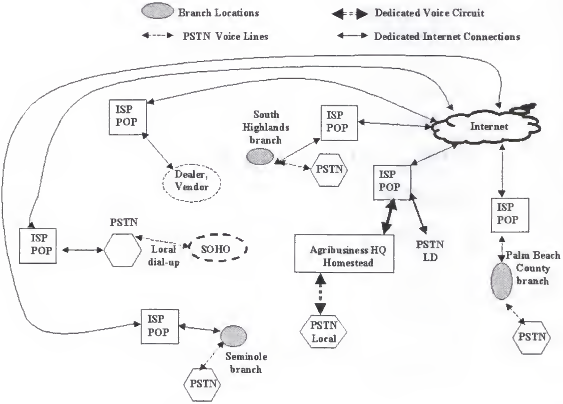

Figure 4-59: Data and IP long-distance VPN over the Internet.

A data VPN requires the agribusiness use the special edge devices called authentication servers. Authentication servers, (together with other equipment) encrypt and packetize data and set up secure tunnels (virtual circuits). These virtual circuits replace expensive dedicated point-to-point or circuit-switched links (three in Figure 4-58) with private Internet connections. A greater capacity Internet connection will likely be needed between HQ and the ISP POP (shown as a bold arrow). Additionally, some of the branch offices (all shown with dedicated Internet connections) may need to establish greater capacity Internet access connections. Only a detailed analysis of bills and expected charges can answer whether changes should be made.

Depending on the devices used the migration from pre-VPN communications to a data VPN may not be noticed by users. Indeed, SOHO dial-up users will find it easier to use the new system (such as Figure 4-60) if they have always-on Internet access connections such as DSL. However, there can be important QOS issues such as reliability that put a damper on a complete migration from three separate connections (PSTN voice access, private data network access, and Internet access) into a single access connection. Before getting to the possible savings by migrating to voice, IP in addition to a data VPN (Internet, Intranet, and Extranet), it is important to touch on technical issues related to IP telephony.

The Internet can be used to transmit and receive packetized, digitized speech over its mixed public-private infrastructure. This is generally known as VOIP (Voice over IP). So far, the quality of sound and the latency and jitter inherent in using the Internet as a telephone access and transport network prevent its widespread use in business. However, as standards improve and prices fall, the Internet is becoming increasingly attractive at least for certain levels of voice communication. For example, dialpad.com (a free VOIP service) signed up over six million users for its free long-distance telephone service over the Internet during the first quarter of 2000. While the quality is not equal to the PSTN, it does approach the sound quality of some digital services. It is a free service since the firm gets revenue from banner ads that are displayed while users converse from computer to telephone.

Table 4-39 shows the main technologies used to provide telephone and enhanced telecommunications services via VPNs depending on the kind of Internet access connection and transport level virtual circuits used by the firm. Depending on application and CPE sophistication, the VPN can eliminate per call long-distance charges entirely, forward a salesperson's calls to their home computer and cell telephone automatically, and allow a home-based executive every communications service available at the home office.

Table 4-39: Alternatives to the PSTN: convergent IP voice technologies.

Technology	Acronym translation	Comments
VOFR	Voice over frame relay	Replace voice-only at access and transport levels with frame relay
VOATM	Voice over Asynchronous Transfer Mode	Replace voice-only access and transport levels with ATM
VOIP	Voice over Internet Protocol.	Replace voice-only access level.

VOFR requires a frame relay connection to access the voice network, typically over copper. ATM uses an ATM network to access the voice network or to transport telephone calls, usually over fiber optic cable. VOIP can use any type of Internet connection to carry calls. While all three technologies may be used in VPNs, it is important to note that frame relay and ATM may be used as private dedicated connections or for Internet access. The difference between a private VPN (that uses virtual circuits over a carrier network such as the frame relay cloud) and an IP VPN (that uses the Internet) are not given in detail. Voice and data traffic can travel over both types of VPN. However, QOS and reliability are more easily assured over carrier networks than through the Internet. Prices for carrier systems are higher as well.

AT&T lists five categories of VOIP, shown in Table 4-40 [Tower, 1999, Ch.9, p. 17]. The first is PC to PC VOIP. Specially equipped PCs using voice communications software can "call" other computers over the Internet and have near real-time or real-time conversations. Each PC must have a microphone and speaker (or better yet special earphone -mike headsets) as well as a sound card, compatible voice communication software, and Internet access. Users at each end must be online at the same time to make or receive calls, a requirement that makes it difficult for dial-up users to get calls unless the time is arranged in advance.

Next are PC to PSTN VOIP calls. These require compatible software and peripherals on the computer end as well as an Internet connection. To connect the Internet to the PSTN, the system must use IP over the Internet to connect to a CO on the other end. VOIP connections must be paid for on a wholesale basis and resold to the agribusiness, or it is possible that agribusinesses may use free calling using a service that underwrites Internet to PSTN connections through banner advertising.

Table 4-40: AT&T's five VOIP categories.

Category	Connections	How implemented
PC to PC	Internet only	Agribusiness CPE and DTE
PC to PSTN telephone	Internet to POP to PSTN telephone.	Via Java or special webpage.
PSTN telephone to PSTN telephone	PSTN telephone to POP to Internet to POP to PSTN telephone.	VOIP implemented by ALEC, ILEC.
Premises to Premises	PBX to POP to Internet to POP to PBX	Agribusiness CPE and DTE, special carrier services.
Premises to Network	PBX to ISP POP to provider network.	Private data network carrier service.

One kind of single access connection (usually the least expensive) is a fully converged IP VPN as shown in Figure 4-60. The VPN shown uses PSTN telephone to PSTN telephone VOIP and a fully converged architecture. Here all local and long-distance calls travel as IP packets over access level and transport level via Internet connections (or a carrier's private IP network). Such a service is not ready currently, but some agribusinesses (those with SONET, T-3, or ATM service availability) are expected to be able to get this service.

Figure 4-60 differs from Figure 4-59 in several ways. First, PSTN voice lines are replaced by Internet access since local and long-distance calling at all branches is done through the Internet connection. A single dedicated voice circuit for local PSTN calls is kept at the headquarters location. Under this configuration, a local call (no matter where a user is located) is a call that is defined as local in Homestead. For some providers, that would include the entire

Southeast LATA so that calls from Homestead to Sebastian Inlet would be local. The Seminole County branch and South Highland branches would use long-distance circuits to reach what would normally be classified as local calls in their locations but use the Homestead PSTN link for calls in the Southeast LATA. Incoming calls throughout the entire company would go through LEC facilities in Homestead and travel through the Internet VPN to reach their destination. In theory, these changes would not be noticed by users, but in practice IP telephony is not yet a business class service capable of replacing LEC service from the point of view of most agribusiness managers. QOS problems are simply too large. However, technology is developing quickly in these areas.

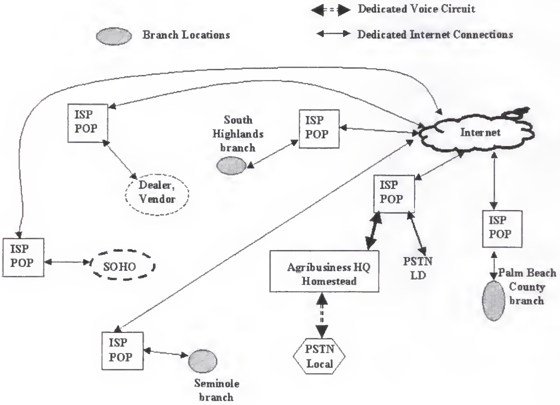

Figure 4-60: Hypercommunications network: Internet-only IP VPN.

Another way Figure 4-60 differs from 4-59 is that all PSTN calls for SOHO users are made over the Internet connection. Since voice traffic goes through the Internet connection, it is possible that a greater capacity Internet access connection will have to be purchased. While every branch office in Figure 4-60 has but one communications link to the outside world, the Internet connection, the agribusiness will write two checks in most cases. Most wireline Internet access requires a separate charge for the agribusiness to ISP POP and for the ISP to Internet NAP. One advantage of new fixed wireless providers is that only one charge is necessary.

Premises to premises VOIP does not replace local telephone service, but may also be used in situations such as Figure 4-60 when all long-distance and interoffice calls travel over the VPN. Under this method, inter-office calls (within the agribusiness) do not incur toll charges or travel over the PSTN. Long-distance calls travel over the Internet to a long-distance provider (PSTN LD in Figure 4-60). From that provider they travel over the PSTN to reach a regular telephone. The definition of local calls may vary (as mentioned earlier) depending on the carrier.

The last entry in Table 4-40 is premises to network VOIP, which replaces access level connections (such as ISDN-PRI or dedicated T-1s) from the agribusiness to a LEC POP or an ILEC POP. Instead of being circuit-switched from the agribusiness through the local telephone companies CO facilities, telephone calls travel over the Internet access route. Premises to network services are likely to be divided between local telephone service and long-distance telephone service, traveling over the PSTN from the provider's POP.

The decision to migrate from three separate networks to a data VPN with voice on the side or an Internet-only VPN must be made based on costs, QOS considerations, available technology, and the type of firm. Moving from separate enhanced telecommunications (PSTN networks), private data networking, and Internet connections (as shown in Figure 4-58) to a VPN (as shown in Figures 4-59 and 4-60) requires that agribusinesses perform a cost-benefit analysis. When costs are restricted to the recurring costs of circuits alone, it is difficult not to adopt a VPN.

4.9.8 Security, Privacy, and Use Policies

Security was already discussed in the context of QOS and in 4.5.1 under protocols and standards. However, the Internet has its own set of security and privacy issues. This short discussion builds on the previous discussion of security as a dimension of QOS in Table 4-3 in 4.2.3.

Internet security is an ongoing concern that includes more than just security hardware or software. Current and future security hardware, software, consultants, programmers, and authorization scripts are additional elements that may be needed. A continued stream of human resources, new technology, and software upgrades are likely to be needed to keep the agribusiness securely connected to the Internet. Security precautions are something like insurance. For most agribusinesses, nothing serious will happen, especially if the Internet is not used to its full power.

The specifics of security are so complicated that all this discussion can do is identify the actors involved in six distinct areas of each agribusiness' Internet security drama. One of the worst mistakes that can be made is to concentrate only on publicized threats such as those posed by hackers and crackers while ignoring more likely threats posed by employees, customers, and competitors.

The motivations of some outside groups (hackers, crackers, samurai, and vandals) reveal the subtle variations in risk involved. Hackers argue that they are often incorrectly described as " . . . malicious meddlers who try to discover sensitive information by poking around. Hence `password hacker', `network hacker'. The correct term for this sense is cracker." ["The New Hacker's Dictionary", 2000, p. #hacker]. Hackers define themselves as people who:

> . . . enjoy exploring the details of programmable systems and how to stretch their capabilities, as opposed to most users, who prefer to learn only the minimum necessary. 2. One who programs enthusiastically (even obsessively) or who enjoys programming rather than just theorizing about programming." [The New Hacker's Dictionary, 2000, # hacker]

However, such individuals would be harmless except that hackers subscribe to a hacker's ethic, which consists of:

> 1. The belief that information-sharing is a powerful positive good, and that it is an ethical duty of hackers to share their expertise by writing open-source and facilitating access to information and to computing resources wherever possible. 2. The belief that system-cracking for fun and exploration is ethically OK as long as the cracker commits no theft, vandalism, or breach of confidentiality. [New hacker's Dictionary, 2000, #hackerethic]

Hackers feel that exploring a system without permission is philosophically allowable, though they draw the line at outright criminal activity or evil intent. Crackers and vandals are the outside actors that can typically do the most damage to business. Both have malicious (even criminal) intent and both will target a particular web site or business connected to the Internet for the sheer enjoyment of inflicting damage, making a profit, or causing embarrassment. Some crackers and vandals also attack based on political motives such as to further radical environmental or animal rights causes. Samurai are crackers and vandals who hire out their services to help businesses fortify their Internet security.

However, crackers and vandals may be encountered less frequently and do less damage than several groups of other actors such as customers, employees, vendors, and agents. Many insiders may have no ill intent whatsoever, but be capable of exposing the firm to more risk than an outsider. Especially dangerous can be ex-employees or agents (such as web designers, programmers, or other contract personnel) with a specific agenda.

From the point of view of agribusinesses, the distinction among these groups may seem unnecessary. However, understanding the possible threats helps the agribusiness understand the protective measures that are necessary. Some sites, such as those for larger firms or those that operate in politically sensitive environments are more at risk than the typical agribusiness. However, other individuals such as customers, vendors, shareholders, and employees are also potential victims of crackers.

Six security, privacy, and use areas are summarized in Table 4-41 that provide a general overview of Internet security for agribusinesses. The possible dangers posed in each area (and the specifics of each) are too involved to list here. Furthermore, the DTE, DCE, OS, web software, and the staff combine to create a unique security posture for each agribusiness. Therefore, these six areas are a broad description of an area that every agribusiness with an Internet presence must be prepared to deal with.

Table 4-41: Internet security, privacy, and use policies for agribusiness.

Item	Comment	Responsible parties
Security of self-hosted or collocated website.	Defense from denial of service attacks, site theft, hacking, cracking, other threats. Protection of sensitive content, unauthorized access to subscriber material, prices, or wholesale-only parts of site.	Agribusiness.
Security of hosted website.	Defense from denial of service attacks, site theft, hacking, cracking, other threats. Protection of sensitive content, unauthorized access to subscriber material, pricing, or wholesale-only parts of site.	Web host. Agribusiness responsible to check, report problems.
Security of restricted access areas of websites	Protection of sensitive content, unauthorized access to subscriber material, pricing, or wholesale-only parts of site.	Programmer, hosting firms (if applicable)
Security of self-hosted Internet domain and IP's	Protection of all machines connected to Internet including e-mail servers and databases, firewall and proxy server operation, virus prevention, detection, and decontamination.	Agribusiness and ISP access provider.
Security and privacy of customer data	Protection of customer data such as names, buying history, credit card information, e-mail addresses, etc.	Agribusiness, programmer, web host and third parties (if applicable).
Security, privacy and use policies governing company and employee information and communications.	Password and security policies, e-mail security and use policies, web surfing privacy and use policies, Intranet policies, ownership of intellectual property, consequences of violations.	Agribusiness and employees.

The first area of Internet security concerns the self-hosted or collocated website. Responsibility for this area is solely the agribusiness' unless it hires an outside security firm as a consultant or manager. A few threats that can occur to self-hosted or collocated web sites include denial of service attacks, site theft, hacking, cracking, and vandalism. Danger here is to material on the web site or rented server space alone.

Denial of service attacks are concerted efforts by an individual or group to "flood" the web site with traffic, making it unreachable to visitors. Site theft occurs when DNS entries are illicitly changed so that the agribusiness' domain name points to an unauthorized IP address, or the contents of a web site disappear to be replaced by unauthorized content. Vandalism occurs when a web site is broken into and portions are erased and replaced.

If the agribusiness monitors its web site regularly, such problems can be noticed quickly. Site theft or vandalism are typically resolved quickly with the help of the ISP or NSP that hosts the DNS. However, site theft and vandalism, while small risks, are another reason a full backup of the site is essential. Denial of service attacks are rare except for larger sites, where federal and state authorities can typically step in and put an end to them.

If the website is hosted by a hosting company, the same security concerns just mentioned still apply. In that case, the hosting firm has more responsibility than the agribusiness. However, the agribusiness may have no control or knowledge about the security policy of the ISP. When shopping for a hosting company, it is a good idea to inquire about security policies and programs if the agribusiness plans to include sensitive material on the site. If a disgruntled employee of the hosting company wants to get even, it may be at the expense of an innocent client's web site. Constant monitoring of the site can help nip problems in the bud.

The third area concerns the protection of sensitive content, preventing unauthorized access to subscriber material, prices, or wholesale-only parts of site. Hackers may feel they have the right to browse any information sold to subscribers from the site and share it with others out of a misguided desire to make information on the Internet free. Crackers may offer to sell information to competitors or sell it themselves on the Internet, enter false orders, or otherwise wreak havoc. Many of these risks apply only to agribusinesses with B2B e-commerce sites or subscriber material. Remedies include properly programming and testing the site beforehand, and regular review of password and activity logs. Customers themselves may download material and attempt to deal with other suppliers using prices or to gain discounts if they find evidence that others are getting better deals. Employees may accidentally put material on the web that should not be there. Again, danger in this area are related to material on the web site itself, but specifically material intended not to be widely seen.

When the web site is hosted elsewhere, the responsibility for protecting restricted parts of the site may be shared among the hosting firm, writers of programming code (such as authentication software), web designers, and the agribusiness. Dangers include protecting sensitive content from competitors or hackers and the prevention of access to subscriber material. For some agribusinesses, access to prices or wholesale-only parts of site could harm relationships with existing customers or prevent new customers from buying. Passwords used by site designers, programmers, or former customers or employees should be revoked once they no longer have access rights. It may be difficult if not impossible to learn of some violations, so be careful of what is put on the company website.

Another security area is the security of self-hosted Internet domain and IP's. Agribusinesses with only a web presence and lower level Internet access will not have to worry about this issue much, but those who have computers at the business that can directly connect to the Internet do. At stake is protection of all machines connected to Internet including e-mail hosts and databases, the operation of firewalls and proxy servers, regular updating of anti-virus software, and patches for e-mail and browser software.

The fifth security area is the security and privacy of customer data. Government and industry self-regulators are both looking at this area, which includes such things as the protection of customer names, buying histories, credit card information, e-mail addresses, and any other individual-level data regarding customers or vendors. The agribusiness can do three things. First, if information of any kind (from e-mail addresses to credit card numbers) is requested from customers, a clearly-worded privacy policy should be stated. The privacy policy should be prominently featured before information is gathered to allow customers to decide whether they want to opt-out before giving information. Second, the agribusiness needs to follow that policy or risk possible legal action or bad publicity. Third, customer information should never be left on publicly accessible parts of a web site. It makes sense to review information flows and locations with programmers. Encryption of information and special privacy protocols can help the agribusiness to protect customer data.

The last security issue is security, privacy, and use policies governing company and employee information and communications. These include password policies, limitations on copying and transfer of information, e-mail security and use policies, web surfing restrictions, and other use policies. Varian comments that "The big problem with security is not the hardware or the software, but the user. The users just haven't developed the habits that are going to be appropriate for living in that electronic environment [Varian, 1996, p. 45].

Two issues are at stake concerning employee security and use. First, the security of the company's system must be protected from accidental or intentional compromise. Passwords of dismissed employees should be immediately revoked. Since the vast majority of employee security problems are accidental, the network should be rigorously safeguarded from accidents. Second, the manner in which employees are expected to behave while online can affect communication with customers and resource allocation. The consequences of violating policies and reasons for their importance should be made plain. Internal or external circulation of material that might be considered sexually explicit or racially discriminatory could draw the agribusiness into unwanted legal proceedings since e-mail can be preserved forever for harassment claims. Employees should also be told what appropriate e-mail and Internet use is, and whether their use has any expectation of privacy.

4.9.9 E-Agribusiness, E-Commerce, and Customer Service

One of the most active areas of the Internet and hypercommunications in general is e-commerce. Estimates of the dollar value of e-commerce differ dramatically. In March 2000, the U.S. Census Bureau reported that retail e-commerce sales in the fourth quarter of 1999 reached

$5.3 billion [U.S. Census Bureau, *Monthly Retail Trade Survey*, March 2, 2000]. While the Census Bureau admitted that this amount represented a scant 0.64 percent of total retail sales for the period (estimated at $821 billion), by some estimates e-commerce revenues grew to four times what they were a year earlier [Nua *Internet Survey*, 110(1), January 24, 2000]. Forrester Research estimated that the value of U.S. business-to-business e-commerce alone stood at $109 billion in 1999, with the total expected to climb to $1.3 trillion for 2003 for business-to-business and $108 billion for retail [Nua, 2000]

Depending on the definition, e-commerce encompasses electronic trade of all kinds resulting from web sites, online auctions, Extranets, and other sources. The definition is beginning to be more difficult as firms are merging web sites and IP CTI call center operations into simultaneous shop by web and by telephone services. Whatever the precise definition, the origins of e-commerce strategy arose from the e-business model first suggested by IBM in 1997. IBM's official definition of e-business is "The transformation of key business processes through the use of Internet technology." [IBM, 1999] These business processes affect two flavors of e-commerce, business to consumer e-commerce and business-to-business (B2B) e-commerce.

E-commerce covers a great deal of territory. The economic issues that formed the source of the information economy were covered in Chapter 2, while some economic and technical aspects of hypercommunications were covered in Chapter 3. Elsewhere in Chapter 4, a discussion of what hypercommunications are brings in more of the e-commerce picture. While this short discussion could expand to encompass a Chapter of its own concerning the details of how specific hypercommunication services and technologies drive e-commerce, it makes more sense to cover the broad philosophy. Many of the details have been covered by the chapters just mentioned.

According to IBM, the focus of e-business is "on business, not technology". However, new technologies probably drive e-business just as much as e-business drives technology. Indeed since the ITU maintains that "today technology is in search of applications", innovative e-agribusinesses who discover e-commerce applications of new technologies could profit handsomely [ITU, 1995, p. 8]. However, IBM focuses on the business viewpoint rather than the engineer's when it names four stages of an e-business cycle.

The first stage of IBM's e-business cycle is "to transform core business processes" [IBM, 1999]. This means that an agribusiness (at the very least) must computerize and automate transactions with its largest buyers and its largest vendors. On the B2B side, core business tasks are included within two philosophies, EDI (Electronic Data Interchange) and SCM (Supply-Chain Management).

EDI encompasses data integration, application integration, and middleware integration. The data to be integrated include such things as purchase orders, requisitions, and invoices through online processes. Application software can be integrated so separate companies can work in concert through common sales tracking, inventory management, accounts receivable and payable, and general accounting. Middleware allows one business' software to communicate with another business'. EDI is most cheaply implemented through an Internet VPN, though performance issues can outweigh cost savings. Private data networks such as managed frame relay may be preferred. However, EDI offers limited information sharing and thus does not encourage e-business integration as well as SCM does [3com, 2000]

SCM (Supply-Chain Management) is an especially important B2B philosophy for agribusiness. SCM approaches seek to get parties at all levels of the marketing chain (retailing, raw materials, manufacturing, processing, distributors, wholesalers, as well as transportation and shipping) involved through a common B2B network. SCM involves the "planning and control of the flow of goods and services, information, and money electronically back and forth through the supply chain." [3com, 2000, p.15] SCM systems may require elaborate security layers and may therefore, rely less on VPN Extranets and more on private data networking technologies.

SCM can be especially important to B2B agribusiness applications for several reasons. First, the high perishability and short market windows of many agricultural products such as produce makes rapid communication and coordination from farm to retail important. Secondly, the tendency for many marketing functions to lie between the farmer and the consumer means there can be more opportunity for miscommunication, error, and financial default. SCM can help prevent such problems or when they do occur, help to resolve them. Third, the ability to incorporate SCM into agricultural marketing may improve efficiencies in the structure of the marketing chain, possibly cutting levels with better information and allowing consumers to pay less or get more.

A fourth reason SCM is important to agribusiness comes from the importance of farm to consumer information to accompany products through the distribution chain for food safety or other reasons. For example, consumers may require information about the source and history of organic produce. Batch information can help products to be pulled rapidly and investigations completed more quickly in food safety scares. Another example concerns the use of genetically engineered crops. Finally, SCM is often required for small organizations in order to do business with large buyers. For example, if a grower wants to sell nursery plants to Wal-Mart or other large chains directly, he may have to do business the buyer's way through an SCM.

On the retail e-commerce side, transforming core business processes requires that e-agribusinesses realize that, in addition to providing a good, they are providing a service, the e-commerce experience. Customer satisfaction is a function of the quality of the good or services the e-agribusiness sells, pricing, and the quality of the e-commerce application (service) that consummates the sale. One way of thinking about this is through the disconfirmation model where the customer's evaluation of service quality is a function of customer experience minus expectations [Iacobucci, Grayson, and Ostrom, 1994].

An e-business extension of disconfirmation is that customers will be satisfied and likely to be returning customers if their online purchase experience is greater than their expectations of buying online. Even if the good or service is of excellent quality, customers may be still more disappointed than satisfied. Disappointment can occur even with a quality product if orders arrive late, are never received, are billed twice, if the web site crashes, or if consumers get the BSOD during the ordering process. The agribusiness may be powerless to affect consumer expectations since consumers may expect the same kind of rapid shipping response or shopping cart program used by amazon.com or other firms they have online experience with. However, it is possible that the comparison might be positive given Andersen Consulting's finding that 25 percent of all attempts to purchase an item failed on the 100 top retail web sites during the Christmas 1999 season [Nua, 2000].

The second stage in IBM's e-business cycle is "building flexible, expandable e-business applications." [IBM, 1999] This has been touched on during 4.9.4 (web design, programming, and maintenance). For most agribusinesses, at least until their e-agribusiness efforts succeed, the applications and programming to be used in e-commerce will be developed by outside programmers. As with hiring a web designer or selecting an ISP, agribusiness managers should ask around for references and always view as many working samples of an e-commerce programmer's sites as possible.

Flexibility and expandability of applications refers to more than programming. Agribusinesses have to make sure their web site design and e-commerce applications are flexible enough to handle their needs. A shopping cart function may have to be flexible enough to allow overseas orders, orders from one customer shipped to multiple addresses (such as gift fruit or flowers), and other expected (or unexpected) variations from the typical single order. One florist's shopping cart application required customers who were ordering multiple bouquets (as much as forty percent of their business) to enter their name, address, and credit card number repeatedly rather than once. Internet shoppers may have tighter time constraints than other customers so they are likely to be less patient with inflexible ordering schemes. Expandability concerns whether the e-commerce system can expand to handle more individual items, a greater number or orders, retail and wholesale orders, password protection, etc.

The third stage is "running a scalable, available, safe environment." [IBM, 1999] Clearly, this refers to the 25 percent failure rate obtained by Andersen Consulting which suggests that "sites crashed, order forms corrupted, and goods never arrived." [Nua, 2000] In addition to the obvious implications for the web site Internet connection this stage of the e-business cycle also concerns security, privacy, and how quickly the e-commerce site could expand should it prove more popular than expected.

The fourth stage is "leveraging knowledge and information" the business has "gained through e-business systems." [IBM, 1999] There can be an enormous amount of information about what products sell better, to whom, as well as sources of B2B strategies and tactics. Transaction logs need to be examined along with web site management statistics with an eye towards using the information they contain to refine the e-commerce program.

4.9.10 New Media: Broadcast and Content Delivery

For the sake of consistency, new media, Internet broadcast and content delivery services and technologies need to be mentioned. However, there is little new material to cover. The main point of interest is the ability of agribusinesses to produce and unicast, broadcast, or multicast their own text, audio, and video content. There are also new opportunities to tie in with traditional media outlets (and their web presences) through traditional advertising, web site promotion, and highly targeted banner ads.

Until the Internet, broadcast, multicast, and other content delivery technologies meant traditional advertising-supported broadcasting and publications or possibly unit-priced products such as pay-per-view TV programs. Because of the comparatively low cost of production and transmission, new media allow almost any person or business to broadcast or multicast delayed, delayed interactive, real-time or real-time interactive content over the Internet. While spectral radio and television broadcasters have a limited supply of spectral bandwidth, virtual broadcasters may buy as much as they need according to a hierarchical set of cost constraints that depend on operational scale. Miles provides a webcasting-specific definition of bandwidth in 1998 as a:

> . . . measure of bits per second or transmission capacity of data sent over a particular wire, cable, satellite, fiber-optic, cable, interface, or bus. More bandwidth is needed to send faster and more complex data and assure accurate and real-time delivery. Thus, audio and video, datacasting, and webcasting require more bandwidth due to the complexity and swiftness of changes than does ordinary text or phone communications. So, the larger the bandwidth, the greater the quality and capacity of voice, video, or data. Bandwidth also refers to the range of frequencies that can be passed over a given channel. [Miles, 1998, p. 388]

Unlike TV and radio broadcasters, there is not even the vestige of notions such as "equal time" or "equal access" present in the almost unregulated frontier of cyber broadcasters. The agribusiness may use multi-media technologies to assume the roles of producer, advertiser, company trainer, and PR person.

The changes hypercommunication brings (through the Internet) to the traditional broadcast and content delivery market are summarized in Table 4-42.

Table 4-42: Traditional broadcast and content delivery services.

Service	Traditional agribusiness involvement	Multimedia possibilities
Broadcast Television (VHF & UHF)	Advertiser or news story.	Tie-ins with station websites, banner ads, link exchange
Broadcast Television (digital, HDTV)	None	Unknown
Local radio programming	Advertiser or news story.	Tie-ins with station websites, banner ads
Newspaper	Advertiser or news story.	Tie-ins with newspaper websites, banner ads, link exchange
Magazine	Advertiser or news story.	Tie-ins with magazine websites, banner ads, link exchange
Cable TV	Advertiser	Highly targeted advertising to Cable TV content directly related to agriculture. Tie-ins with portal sites for cable modem customers.

Traditionally, the only way agribusinesses could get TV, radio, or newspaper attention was to buy an advertisement or try to place a news story. The interaction between an agribusiness and traditional media vehicles have been shaped by endless multimedia possibilities. Agribusinesses can use web site promotion tools and new kinds of advertising strategies (such as banner ads) to put their messages before Internet audiences of the traditional media as shown in Table 4-42. However, the value of the Internet goes beyond simply extending traditional broadcast and content delivery services to the new media.

Agribusinesses can use multimedia broadcast and content delivery over the Internet to deliver content they produce themselves as Table 4-43 indicates.

Table 4-43: New media: broadcast, multicast, and other content delivery technologies.

Technologies	Distribution	Purpose
DVD or CD production	Physical, by unit.	Catalogs, ordering software, video demonstrations.
IP multicast	One-to-many transmission via Internet or private data network.	Efficiently transmits text, data, audio, or video to a multicast group. Unreliable, connectionless.
IP unicast	One-to-one transmission via Internet or private data network.	Transmit text, data, audio, or video to single recipient.
IP broadcast	Real-time transmission of announcements, auctions, conference calls, or investor discussions via Internet using special browser plug-ins such as Real Media, Windows media viewer.	All live transmission of one-way audio or video web events.
E-mail feed	Internet via LISTSERV or other mailing list.	Distribution of newsletters, specials, service bulletins, etc. to voluntary subscriber list.
Push technology	Agribusiness sends data to another computer without specific request.	Netcasting or broadcast news technology. Java tickers. True push is actually multicasting.
Pull technology	Visitors to site request information.	Web browsing, FTP.
Subscriber-based web pages	Via WWW to people with passwords.	Access to special pricing or other information. Especially for wholesale customers, preferred customers, or employees.
Subscriber-based e-commerce	Via WWW or Extranet to people with passwords.	Access to preferred customer or wholesale ordering screens and specialized pricing.
Message delivery	Faxes or voicemail via e-mail, pager, or PSTN	Automated forwarding of information or e-mail to pagers, wireless telephones, fax machines, or other devices.

Most of the list in Table 4-43 has been explained and discussed in Chapters 3 and 4. Agribusinesses can create and distribute their own multimedia content directly or through their web sites. With multicasting, instead of sending information in separate messages and packets to each receiver, one message goes out but is broken up as it reaches its destination. Hence, the agribusiness can send relatively large amounts of content over its own Internet connection only once, but each member of the multicast group receives the entire contents separately. Multicasting requires a specialized infrastructure called the Mbone (Multicast backbone) that uses mrouters capable of transmitting multicast packets. Specialized software and protocols may also be necessary. For these reasons, not all ISPs are capable of supporting multicast so the agribusiness must find an ISP that can support multicast. However, viewers' machines (or other terminals) must be equipped with software that can display the programming.

As agribusinesses prepare new media content they are creating intellectual property. Peters describes a "value chain" of "productive relationships between creators and users of intellectual property. The first element is the creators or authors of the new media content. They may be employed by or hired by the sellers or publishers of such content, such as an agribusiness. Typically, as part of the creation process the agribusiness will purchase rights to air, transmit, and copy the material through the third element, intermediaries. Intermediaries may be mere carriers such as ISP or partners who help distribute the material for a portion of the proceeds. Finally, buyers such as libraries, other firms, or individuals (libraries), and end users (readers) complete the value chain [Peters, 1996, p. 139]. Over the Internet, there is seldom a guarantee that end users or buyers will not copy and exchange the material themselves, thus putting a premium on recovering production costs with the first distribution.

This section has hardly touched on all the possibilities new media have for agribusinesses. However, most of the advice given concerning other Internet services and technologies applies here. Specifically, content production is another make or buy decision that the agribusiness must evaluate after doing research about its own needs. An in-house production effort may require the purchase of expensive equipment and the hiring of experienced people. Hiring from the outside should be done using caution and research concerning past results the new media production firm has achieved.

Now that the chapter has explored what hypercommunications are in detail, it is time to offer an executive summary of what has been found that is of use to Florida agribusinesses. Other important material will be revisited in Chapter 6 when specific agribusiness needs and current market trends are covered.

4.10 Summary

The best way to explain what hypercommunications services and technologies are is by reviewing the Chapter in Figure 4-61 below. The seven layers of the OSI model are important regarding technical issues of private data networking and the Internet. However, for most agribusinesses now, the QOS levels (shown together with application level or value-added services in Figure 4-61) represent the best way to characterize the choices available to Florida agribusinesses.

The bottom of the figure represents the local, physical level that contains the agribusiness' own local communications network and equipment. Most agribusinesses have some computer equipment that may be used for private data networking or the Internet and telephone equipment used to connect with the PSTN. The larger an agribusiness is, the more dependent on technology it is, and the more it has to communicate over long distances, the sooner it is likely to try to converge voice, Internet, and data into a single hypercommunications network. On the agribusiness premises, convergence means that its currently separate voice, Internet, and data equipment and currently separate conduit will evolve into a unified whole.

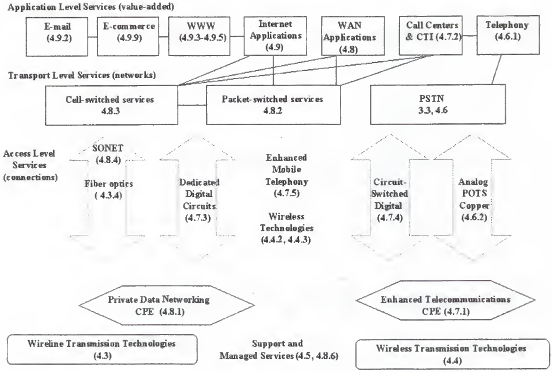
Application Level Services (value-added)
E-mail (4.9.2)
E-commerce (4.9.9)
WWW (4.9.3-4.9.5)
Internet Applications (4.9)
WAN Applications (4.8)
Call Centers & CTI (4.7.2)
Telephony (4.6.1)
Transport Level Services (networks)
Cell-switched services 4.8.3
Packet-switched services 4.8.2
PSTN 3.3, 4.6
Access Level Services (connections)
SONET (4.8.4)
Fiber optics (4.3.4)
Dedicated Digital Circuits (4.7.3)
Enhanced Mobile Telephony (4.7.5)
Wireless Technologies (4.4.2, 4.4.3)
Circuit-Switched Digital (4.7.4)
Analog POTS Copper (4.6.2)
Private Data Networking CPE (4.8.1)
Enhanced Telecommunications CPE (4.7.1)
Wireline Transmission Technologies (4.3)
Support and Managed Services (4.5, 4.8.6)
Wireless Transmission Technologies (4.4)

Figure 4-61: Chapter 4 summary.

However, even if technology allowed smaller agribusinesses to unify their networks and even if the CPE needed to do the job was available, a high-speed connection to access the advanced hypercommunication network of the future would be needed. In many places in Florida, this last mile connection is not yet able to handle convergence inexpensively if at all.

There are several reasons the promise of the future is hindered by the reality of the present. The infrastructure that connects a communications provider's POP to the agribusiness location varies from one location to another. Currently, wireline service may rely on the copper loop from the ILEC, a hybrid fiber-coax mix from the cableco, and the ability to connect directly to a fiber optic network. Wireless access can be fixed, nomadic, or mobile depending on the movement of the user. Of the three kinds of wireless access, only fixed terrestrial is likely to compete sufficiently with the wireline infrastructure. However, most providers (wireline or wireless) have not worked out all the kinks in urban areas to provide a single link to businesses. In rural areas, the situation is even less developed.

In the future, a particular agribusiness may be able to obtain high-speed network access from competing providers and services for each of these four sources. At present, many agribusinesses can obtain high-speed dedicated digital or circuit-switched digital access over copper from a single provider, the ILEC. Larger agribusinesses with offices located in urbanized areas may have more providers (ALECs) willing to serve them by reselling the ILEC's copper loop or by using a fiber network that bypasses the local copper loop. Suburban locations may have cable or DSL access. However, most of these access level services are sold separately for Internet, data, and telephony.

Once agribusinesses can obtain a single high-speed access level connection to transport level services (PSTN, ATM, and packet-switched networks) they will benefit from converged hypercommunication networks. Now, transport level services are available and affordable only by large, strategically-located agribusinesses. As communication needs change, technology improves, and costs fall, transport-level services such as ATM should become more available and more demanded by Florida agribusinesses.

Application-level services or value-added services are currently available at least at low speeds to most agribusinesses. New kinds of application level services and value-added services will increase the benefits of high-speed hypercommunication networking. Even if high-speed access to intelligent networks were available to all agribusinesses today, there have to be demonstrable business reasons to adopt convergence technologies today. It may be expected that the earliest agribusinesses to foresee innovative uses of hypercommunications will achieve supernormal profits from their use. This, in turn, will entice others to follow them. Just as with other technological changes, those who are slow to act may be left behind.

Now that a picture of what hypercommunications services and technologies are has been painted and some of the most promising ones for agribusinesses have been identified, the job is not over. Next, it is important to consider to what role location will play along with taxes and other government policies in allowing hypercommunications to reach rural locations.

CHAPTER 5
INFRASTRUCTURE, DEREGULATION, AND UNIVERSAL ACCESS

> Consumers in all regions of the Nation, including low-income consumers and those in rural, insular, and high-cost areas, should have access to telecommunications and information services, including interexchange services and advanced telecommunications services that are reasonably comparable to those services provided in urban areas and that are available at rates reasonably comparable to rates charged for similar services in urban areas. . . . [1996 TCA, section 254]
>
> The term advanced communications capability is defined, without regard to any transmission media or technology, as high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, and graphics, and video telecommunications using any technology. [1996 TCA, section 706]

With those words, the U.S. Congress enshrined into law a commitment establishing nationwide access to a broadband [1] hypercommunication network that would serve all areas of the country, including rural areas. The new legislation represented an important departure from the previous state and federal approach to communications because of sweeping deregulatory provisions combined with an attempt to reduce regulatory asymmetries. Under the 1996 Telecommunications Act (TCA), rural interests (including agribusinesses, their customers, and suppliers) have the right to access a greater range of hypercommunication services than the traditional telephony services they had been entitled to under the 1934 Communications Act.

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[1] Recall from Chapter 4 that broadband can be used to refer to a transmission technology (as in broadband, baseband, or carrierband) or to the data rate of the communications pipeline. As used here, broadband refers to the speed rather than the transmission technology in the TCA.

Additionally, the new, high-speed services had to be offered at prices that were "roughly comparable" to those offered to customers in urban areas.

Chapter 5 discusses the *how* and *where* of hypercommunications infrastructure and regulation. *How* refers to how deregulation, re-regulation, taxation, and policy goals such as universal access and universal service will be used as mechanisms to help determine *where* infrastructures are deployed and access is available. The economics of policy responses influence how and where infrastructures will be developed, and what kinds of hypercommunication services will be available to Florida's agribusinesses.

Details of specific infrastructures were found throughout Chapter 4, especially 4.3.2 (telephone), 4.3.3. (Cable TV), 4.3.4 (fiber backbones), and 4.4 (wireless). Service availabilities and the unique hypercommunication needs of Florida's agribusinesses are illustrated in detail in Chapter 6. However, the availability of access to high-speed networking services may be determined by hypercommunications policy in some parts of Florida. A related question to be covered in Chapter 5 is *how much competition* there will be in the provision of hypercommunications to agribusiness and rural areas. Part of this answer depends on regulation, while part depends on the hypercommunications market structure, which is covered in Chapter 7.

As hypercommunications become more of a requirement for profitability and growth in a world economy linked by better communications, rural communities and producers without adequate access to hypercommunications could become marginalized. Furthermore, agribusinesses that must rely on infrastructures in such under-served areas are a disadvantage compared with domestic or international competitors who enjoy better access.

The Chapter begins with a brief overview of rural Florida's hypercommunications environment in section 5.1. Section 5.2 covers the meaning of other central concepts of the regulatory setting: a discussion of what the term rural means, along with definitions of infrastructure, universal service, and universal access. Section 5.3 traces the regulatory history of wireline and wireless communication infrastructures, pointing out how the converging hypercommunication sub-markets (mentioned in the latter half of Chapter 4) diverge from the market definitions of the regulators. Section 5.4 considers several rationales for government involvement in hypercommunication sub-markets. Brief economic analyses of specific mechanisms that are being used currently to extend service to rural areas and regulate hypercommunications in general are given in 5.5. Section 5.6 presents a conceptual model that is then used to analyze three general topics in the economics of utility regulation given that convergence and technical change are outpacing regulation. Finally, section 5.7 discusses several minor rural development measures some that can directly help agribusinesses with hypercommunication planning and needs. Since regulation plays such an important role in geographical market definition, Chapter 6 will use results from Chapter 5 to look at how market boundaries make the local hypercommunication market facing Florida agribusinesses difficult to regulate and define.

5.1 Overview of Florida's Rural Hypercommunications Environment

For many agribusinesses, all or part of their ability to hypercommunicate depends on whether carriers extend inexpensive high-speed access to services in rural areas. However, the cost per subscriber of the rural hypercommunications infrastructure is high compared with urban areas, due to low population densities and other factors. This section gives a brief overview of how high-speed network access technologies affect the rural hypercommunications environment.

One way to understand the magnitude of the problem of extending hypercommunications to rural areas is by examining available data. An excellent source to start with is the FCC's HPCM (Hybrid Proxy Cost Model) data on all telephone, T-1, ISDN, and DSL lines (local loops) in Florida [FCC, CCB, 2000]. HPCM is a model used to estimate the forward-looking cost of providing "advanced telecommunications services" to high-cost areas [Bush, *et al.*, 1998]. The FCC and state utility commissions gathered information about the locations of all local loops throughout every state. The HPCM data are summarized at the exchange or wire center levels on down to small GIS (Geographic Information System) clusters.

Some of the extremes shown in Table 5-1 help to frame the issues involved in rural areas. The heart of the wireline access policy problem is summarized through five variables: average cost per loop of providing, average copper loop length, maximum copper loop length, total area of each exchange or cluster, and line density per square mile.

Table 5-1: Rural Florida ILEC loop length, density, and cost data.

Variables	Highest/largest exchange	Lowest/smallest exchange	Highest/largest cluster	Lowest/smallest cluster
Loop cost	\$156.46 Kenansville (Sprint)	\$13.62 Jacksonville JT-Southpoint (BellSouth)	Not available	
Area	408 mi^2 Lake City (BellSouth)	1.2 mi^2 Jacksonville JT-Southpoint (BellSouth)	14.3 mi^2 Marianna (Sprint)	0.005 mi^2 Big Pine Key (BellSouth)
Average loop length	137,593 feet Everglades (Sprint)	1,973 feet Jacksonville JT-Southpoint (BellSouth)	343,800 feet Perrine (BellSouth)	465 feet Miami Grande (BellSouth)
Longest loop	Not available		468,000 feet Everglades (Sprint)	999 feet Miami Grande (BellSouth)
Teledensity lines/ mi^2	120,278 Miami Grande (BellSouth)	0.84 Belle Glade (BellSouth)	120,278 Miami Grande (BellSouth)	0.66 Eglin AFB (Sprint)

Source: FCC Common Carrier Bureau, 2000.

First, average costs per loop in rural exchanges tend to be high when compared with urban ones. It costs over ten times more per local loop to provide POTS (Plain Old Telephone Service) to Kenansville than it does to parts of Jacksonville. When it comes to DS-0 and higher dedicated lines and circuit-switched circuits the differences in costs are even larger. The investment cost of such dedicated and direct circuits ranges from \$0.40 per line to over \$600 per line per month (in addition to loop costs), depending on the area's infrastructure and average connection length [FCC, CCB, 2000]. Such dedicated and direct loops provide businesses with access to enhanced telecommunications services, private data networking, and the Internet. With these dramatic differences in costs, it is hardly surprising that the full menu of enhanced telecommunications and high-speed data and Internet access are unavailable via telco lines in many areas of Florida.

The area covered by a CO or wire center is another important variable. For example, as Table 5-1 shows, the Lake City CO serves over 400 square miles, while certain COs in both Miami and Jacksonville serve areas smaller than two square miles. Large serving areas are correlated with longer loop lengths. Loop lengths stretch up to 468,000 feet (over eighty miles) in Sprint's Everglades exchange with the average loop length there at almost 138,000 feet. Perrine (south of Miami) has one cluster with an average loop length of over 343,000 feet, while clusters in the downtown Miami Grande exchange are only 465 feet on average from CO equipment.

The longest loop in any cluster in Miami's Grande exchange is 999 feet, while the longest loops in dozens of clusters in other exchanges exceed 100,000 feet (almost nineteen miles). Loop lengths determine two things. First, many circuits such as DSL and ISDN cannot be offered on loops of 18,000 to 35,000 feet or more. Other circuits such as dedicated T-1 lines can be offered to points at greater distances, but only at enormous expense. The added expense results because longer distances may require older transmission technologies that need repeaters every two to six thousand feet, specially conditioned lines, and other expensive qualifying factors[2]. Even 56 kbps modems will not transmit at full speed over long loops. As many as twenty percent of all loops in Florida are 24,000 feet or further from CO equipment.

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[2] There are numerous technical issues related to the extension of particular high-speed service to an area that are covered in detail in Chapter 4. Figure 4-24 (in 4.3.2) and Figure 4-44 (in 4.73) are representative of these issues.

Line density per square mile is another statistic used to determine where high-speed access technologies are likely to be profitable (and hence, deployed). There are enormous teledensity variances within Florida. For example, the Miami Grande exchange has over 120,000 lines per square mile, while Belle Glade has 0.84 lines per square mile. The sparsest area of all is a cluster within the Eglin AFB (in the Panhandle) exchange served by Sprint that has 0.66 loops per mile. ILECs are reluctant to invest in new infrastructure for sparsely settled areas with low densities per mile. Table 5-2 shows the number of total, business, special, home, and single-line business lines per teledensity category in BellSouth's service area during 1999. Teledensities are frequently a favored way to analyze communications and geography because they are correlated with service levels and costs [Kellerman, 1997]

Table 5-2: BellSouth loops by density zone (thousands)

Density zone Loops/mi^2	Total Lines	Business Lines	Home Lines	Special Lines	Single-line business	Households
Digital Loop Carrier (DLC) & Remote Access Vehicle (RAV) Feeder Lines						
0-5	2.9	0.1	2.7	0.08	0.04	2.6
6-99	176.2	19.4	144.8	12.0	2.8	131.3
100-199	136.1	24.3	96.8	15.0	2.7	85.8
200-649	581.4	104.0	413.2	64.2	10.7	360.0
650-849	237.7	45.1	164.8	27.8	4.0	142.8
850-2,549	1,469.6	303.7	978.5	187.4	24.4	845.5
2,550-4,999	574.7	154.1	325.5	95.1	6.2	280.2
5,000-9,999	171.3	56.6	79.8	34.9	0.6	68.2
10,000+	44.3	19.2	13.3	11.8	0.2	11.4
Non-DLC–RAV Feeder Lines						
0-99	5.0	494	4.2	0.3	0.1	4.0
100-199	18.3	3.3	13.1	2.0	0.3	12.1
200-649	70.1	14.0	47.5	8.6	1.1	42.7
650-849	56.5	13.0	35.5	8.0	1.3	31.8
850-2,549	1,328.0	317.7	814.3	196.0	25.9	718.8
2,550-4,999	1,597.2	436.5	891.4	269.3	26.9	781.0
5,000-9,999	717.6	224.3	354.9	138.4	8.4	310.7
10,000+	355.2	159.0	98.2	98.1	2.2	86.4

Source: FCC CCB (2000), HMWKFL2151919999.xls, Excel spreadsheet.

According to Table 5-2, under ten percent of the 1.8 million multiple business lines and trunks were in areas with densities below 850 lines per square mile, and almost one-third lay in areas with over 5,000 per square mile densities. Almost twenty percent of households and single-line businesses were in areas with densities below 850 lines per square mile, with a smaller percentage located in areas with over 5,000 lines per square mile.

Figure 5-1 shows the distribution of loops among teledensity categories. Roughly, about sixty percent of all lines are located in areas with a teledensity of 850 to 5,000 lines per square mile. Approximately twenty-five percent are in areas with higher densities than that and fifteen percent in areas with lower teledensities than 850.

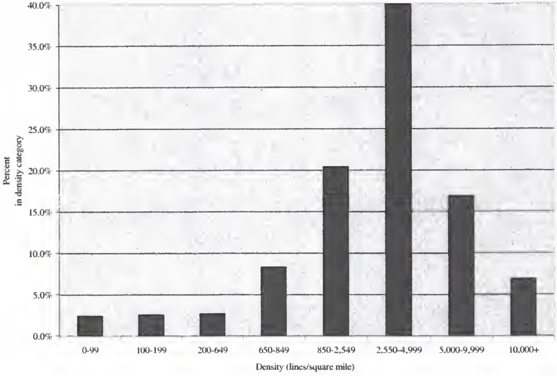

Figure 5-1: Almost 16 percent of BellSouth's lines are in areas with densities below 850 lines/mi^2.

Low subscriber densities and long local loops are not new problems. However, both result from achievement of two former policy objectives of ILECs: deploying POTS lines in high-cost rural areas at prices comparable to other areas and extending POTS to previously unserved places. The REA (Rural Electrification Administration) and RTB (Rural Telephone Bank) were two federal programs that were used to build previous generations of POTS infrastructure in high-cost, low-density rural areas. However, these programs were targeted towards the service territories of small co-operatives and independent ILECs that were certified as rural carriers.

Most of Florida (rural and urban) is served by three large ILECs: Sprint (serving territories of the former Central and United Telephone Companies), GTE (now merged with BellAtlantic-Verizon), and BellSouth, an RBOC (Regional Bell Operating Company). The three large ILECs are classified as non-rural carriers though they serve over ninety percent of Florida's area. Generally, the specific design of rural loop plants in non-rural-certified carrier areas has been left up to the carrier. Often, plans for dedicated circuits, circuit-switched ISDN, and data transmission were left out since the law mandated POTS alone.

In addition to special programs for rural carriers, traditional services and technologies have been subsidized, regulated, and taxed to achieve price equity between urban and rural areas. The methods that have been (and are being) used typically include rate averaging (5.5.1, 5.6.2) and rate of return regulation (5.6.3) by the FPSC. Price cap regulation (5.6.3) is used for non rural-certified carriers. More detail about specific mechanisms is presented in section 5.5, but essentially three transfers (along with overall utility regulation) are used to accomplish the extension of service.

First, business telephone rates are used to subsidize residential service. Prices for business service average two to three times that of residential customers in part so that businesses (which tend to be located in higher teledensity areas) will subsidize residential service (which tends to be found in lower teledensity areas). Second, urban and suburban rates (of businesses and residences) subsidize wireline service to rural areas. Hence, customers in low-cost areas (such as Jacksonville or Miami) pay almost the same rate for telephone (and some other tariffed services) that rural customers in Kenansville or Okeechobee do. These equal costs are charged although it may cost the ILEC ten times or more to provide rural service. The third transfer is through taxation and direct subsidy so that telephone companies that serve high-cost areas are compensated directly for the costs that cannot be met through either of the other two methods.

One bit of evidence supporting the success of these ILEC programs in improving the rural telephony infrastructure can be seen in Figure 5-2. DLC-RAV (Digital Loop Carrier-Remote Access Vehicle) access loop hardware[3] is how the overwhelming majority of telephone subscribers in areas with densities below 850 lines per square mile obtain service. Interestingly, the 850-2,499 teledensity category has a much lower deployment of DLCs and fiber in the loop than more urban teledensities shown on the right.

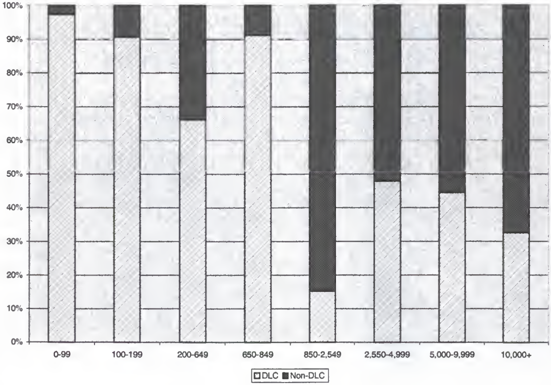

Figure 5-2: Teledensity categories in BellSouth service areas and DLC-RAV coverage.

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[3] Details of wireline infrastructure including terms such as DLC and RAV are covered in detail in Chapter 4.

Cynics argue that Figure 5-2 is evidence of two separate developments rather than one positive one for high-speed access. BellSouth has extended DLC-RAV solutions to many rural areas to save itself money, since many deployments in those locations cannot support high-speed services because of the DLC-RAV equipment used there. BellSouth is now extending newer DLC-RAV technologies (capable of supporting high-speed services) mainly in denser areas (at the right of Figure 5-2) that are financially able to support DSL and other high-speed services.

Before the 1934 Communications Act established a federal mandate to improve rural communications, even the telephone was still far from universal in the United States, especially in poorer, more rural areas. Rural America was considerably behind the rest of the nation in communications infrastructure and Southern rural America even more so. In 1920, for example, fewer than ten percent of Florida farms reported telephones, compared to a national average of 50 percent [*Statistical Abstract of the United States*, 1924, p. 305].

Now rural areas of Florida have basic traditional telephony services and some enhanced telecommunications services. However, the capacity of rural networks to handle enhanced services varies dramatically. Depending on location, high-speed wireline services such as DSL or ISDN-PRI may be unavailable or prohibitively expensive to all but the largest agribusinesses. Although rural Florida has a reasonably high cable TV pass rate, broadband networks built by Cable TV companies do not extend outside city or town limits to low density areas in most cases. Electric utilities including rural cooperatives have begun to provide retail high-speed access to their "dark fiber" capacities. However, most rural electric co-ops either partner with telephone co-ops to deploy high-speed wireline access or remain focused on electricity alone.

Wireless is often seen as the solution for many rural customers. However, in addition to the technical barriers mentioned in 4.4, access varies. Satellite TV services are widely available, but satellite-based telephone and Internet offerings can require expensive CPE and offer asymmetric data rates. DirecPC, the most popular satellite Internet service requires a telephone modem for the upstream path and offers only 400 kbps downstream. Fixed wireless may depend on unobstructed horizons or thunderstorm-free conditions. Many of the most promising fixed wireless technologies such as MMDS and LMDS are not yet deployed and will be targeted towards office building users when they are. Cellular and PCS carriers are beginning to offer third generation services where no long-distance charges prevail; yet, these may lack full functionality in rural regions. In addition to other regulation, wireless hypercommunications is subject to FCC spectrum allocation rules (covered in 5.5.4).

5.2 Rural, Infrastructure, and Universal Service

Now that a brief overview has been given, it is time to provide a better idea of three essential terms used in hypercommunication policy as it applies to agribusiness. This section covers dimensions of infrastructure (5.2.2) and the meaning of universal service and its high tech twin, universal access in 5.2.3. Before these topics can be covered, a few words must be said about the meaning of the word rural. The definition of what constitutes a "rural" area is much more difficult than it at first appears.

5.2.1 Definitions of Rural

The Department of Census, USDA, U.S. Congress, Department of Commerce, FCC, postal service, zoning, and public safety agencies each have different definitions of how populated a certain geographically configured area must be to be called rural. However, when using the term rural with respect to hypercommunication policy, mere recitation of legal, zoning, Census, or USDA definitions is insufficient. The definition of the term rural is also used to divide Florida ILECs (and other carriers) into rural-certified and non-rural-certified to allocate 1996 TCA subsidies that support the extension of service to rural areas. Precise definitions of rural can be obtained with GIS data that pinpoints population densities for any location.

In Figure 5-3 [U.S. Census Bureau, 1998], the 1990 population density of each Florida County is shown. By 1998, the density for the entire state stood at 274 persons per square mile.

The same recent Census estimates showed that Pinellas County (Saint Petersburg) is still the most densely populated County with over 3,185 persons per square mile. Pinellas is followed by Broward County (Fort Lauderdale) with 1,185, Seminole County (Sanford) with 1,146, Miami-Dade County (Miami MSA) with 1,065, Duval (Jacksonville) Hillsborough County (Tampa) with 893, and Orange County (Orlando) with 889 persons per square mile.

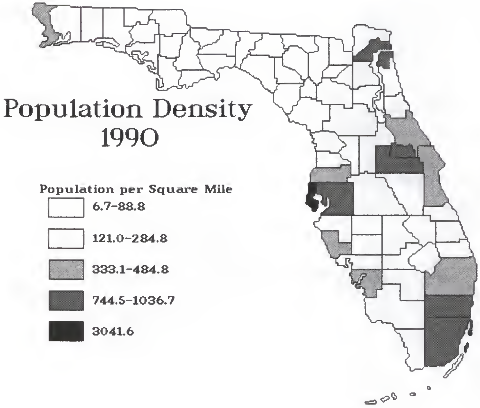

Figure 5-3: Population densities.

Then, a host of less populated cities and counties fall in the 333 to 485 persons per square mile range. Included in that category are Sarasota county (Sarasota), Lee county (Fort Myers), Palm Beach County (West Palm Beach), Escambia (Pensacola), Volusia County (DeLand and Daytona Beach), Manatee County (Bradenton), Brevard County (Melbourne-Cocoa), and Pasco

County. In 1998, the least densely populated counties were Liberty (9.3 persons per square mile), Glades (12.7), and Lafayette (13).

These county-level data show that some areas are more sparely populated than others are. However, communication networks rely on the distribution of population around access nodes such as COs and other POPs. In many counties, the density figure may be artificially low because of unusable wetlands (as it is in Dade, Broward, and Palm Beach counties), and the presence of federal or state land. The tendency to define an entire county as rural or urban based on census characteristics of the whole county's land area is therefore flawed. However, this is not the only problem with defining rural.

There are two additional problems with using county densities to define rural for hypercommunications before several alternative definitions of rural are introduced. First, densities in the fastest-growing counties are creeping higher as agriculture loses land to urbanization. Figure 5-4 [US Census Bureau, 1995]shows U.S. Census estimates of growth by county from 1990-2000, as estimated by the U.S. Census bureau in 1998.

The top three 1990-2000 county population increases in percentage terms were projected to occur in Osceola, Hernando, and Flagler Counties. However, recent estimates suggest that Flagler, Liberty, and Sumter County will each achieve population growth of over 40% from 1990 to 2000. In total numbers, five counties are expected to see increases of over 100,000 people: Broward (180,000), Palm Beach (151,000), Miami-Dade (146,000), Orange (136,000), and Hillsborough (102,000).

Second, average densities of rural population do not tell the whole story concerning the market for hypercommunications services. If rural residents are widely scattered, one technology (wireline or wireless) may be better than another depending on how density is defined. Widely scattered could mean 900 people in a single cluster or 900 people in 900 equally spaced-apart dwellings, depending on how density occurs in reality.

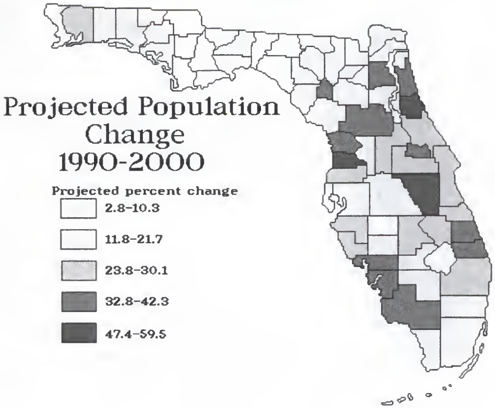

Figure 5-4: Growth in Florida Counties.

Table 5-3 summarizes some of the more frequently used definitions of rural, giving the percentage of Florida's population that falls into each category along with some problems with that definition. The county-based definitions of rural and urban used by the Census Bureau have just been mentioned. Under the census metro versus non-metro county designation, 914 thousand of Florida's population (7.1%) was classified as rural in the 1990 census. An alternate Census definition of rural as persons living outside incorporated and unincorporated CDP places with fewer than 2,500 persons finds 1.97 million rural residents of Florida, making up 15.2% of the total population. The USDA economics agencies use several methods to define rural. For the most rural definitions, a mere 28 thousand inhabitants of three counties made up a small fraction of one percent of the total population.

Table 5-3: Various definitions of rural.

Definition (source)	Description	Florida rural population, 1990 (pct.)	Problems
Metro vs. Non-metro county designation (US Census)	Counties containing cities and metro areas over 100,000 people are classified as urban, remainder rural.	914 thousand (7.1%)	Vast tracts of the everglades and agricultural lands are classified as urban depending on the county.
Rural, non-CDP(Census Designated Places) (US Census)	All population outside incorporated areas and unincorporated areas (CDPs) with less than 2,500 persons.	1.97 million (15.2%)	Does not change except at each decennial census. Some rural population within CDPs and incorporated limits.
Urban Influence codes (USDA, ERS)	1-9 scale based on adjacency to metro areas and population of cities within county not density.	Dixie, Hamilton, & Lafayette are the only 9's (0.02%)	County level.
Rural-Urban continuum codes (USDA, ERS,)	0-9 scale based on population, adjacency to metro area, density.	Dixie, Hamilton, & Lafayette are the only 9's (0.02%)	Complicated, subjective, and county level.
FCC rural-designated carrier serving areas	Population of areas with rural-designated carriers.	193 thousand (1.5%), 14% of land area.	Ignores rural population in BellSouth, GTE, & Sprint territories.
GIS-based	Based on microlevel densities of all dwelling units using advanced mapping techniques.	varies	Requires complex models and large data sets to analyze.
Incorporated vs. unincorporated	Legal	6.52 million (50.4%)	Some incorporated areas have rural areas in them; many unincorporated places are urbanized.
zoning-based	Density of dwellings per acre or tax status.	varies	Requires city and county zoning data, categories vary.

Sources: ERS, 1993, US Census Bureau, 1995; RTF, 2000, p. 21.

FCC rural-designated carriers served a population of 193,000, 1.5% of the state's population on 14% of the land area. The 1996 TCA defines rural telephone companies as those that do not serve either any incorporated location larger than 10,000 inhabitants or to any territory incorporated or unincorporated that is within an area designated as urban by the Census Bureau [Egan, 1996, p. 264]. Regardless of what other definition of rural is used, the FCC rural-designated carrier definition clearly understates the number of rural Floridians. Using almost any other definition of rural, most residents of rural Florida are served by BellSouth, GTE, or Sprint. None of these three large multi-state ILECs meets the 1996 TCA litmus test for rural-designated carriers.

Unincorporated places had over 6.5 million inhabitants, just over 50% of the state's inhabitants in 1990. While most of the population in these locations could not be classified as rural, almost all rural land falls inside unincorporated areas. Each definition has its own strengths and weaknesses as shown in Table 5-3.

Even with a particular definition, the actual physical task of locating, marking, and defining fast-changing parts of the state are difficult. In the FCC HPCM database, a GIS (Geographic Information System) is employed to map communication network nodes, telco exchanges and wire center, flows, directions, and network topologies [FCC, ACC, 2000]. An enormous body of data for nodes, exchanges, ILECs, and regions is available such as that summarized in Table 5-1 and Figures 5-1 and 5-2.

Several final points help characterize the meaning of rural in the agribusiness hypercommunications context. First, rural is not necessarily agricultural and agricultural is not necessarily rural. The proportion of total economic activity in small communities resulting from agriculture varies dramatically, but in all but a few cases is less than half. Estimates of the amount of agribusiness value added in rural or suburban versus urban facilities are hard to find. Typically, the farm gate price (received by farmers or growers themselves) is a small fraction of the full retail price. Depending on the product in question, as much as ten or fifty times of value is added off the farm at processing plants, warehouses, or packaging facilities in urban areas or small towns. Agribusinesses in these areas have a better chance of getting high-speed hypercommunication services than most farms do.

Second, rural and remote are not necessarily synonyms. Compared to states in the western US, teledensities in Florida are not low. Where they are, in many cases long loop lengths do not lead to isolated farms or sugar plants, but instead to vacation hideaways, hunting and fishing facilities, or private islands [Egan, 1996]

Another argument is often heard that if residents of rural areas want high technology, they should move to areas where it is available rather than *vice versa*. Characteristics of non-metropolitan residents are often generalizations, but many people gain considerable utility from living in rural areas.

> Roper organization surveying, published in 1992, shows that 83 percent of non-metropolitan residents say they are family oriented; 69 percent identify themselves as having a strong commitment to their community (only 5 percent of metropolitan residents do). Rural residents are much more likely to give their communities high marks for personal values, friendliness, cost of living, police protection, recreational facilities, low pollution, and quality of life for themselves and their children. Sixty percent of rural residents think their community is moving in the right direction, only 36 percent of urban residents do.
>
> That Roper survey shows 33 1/3 percent of Americans believe that rural America is the ideal place to live --- and 35 percent of all Americans say they would like to be living in a small town in 10 years. [Doll, 1996, pp. 237-238]

This argument may be particularly true of the increasing number farms and ranches where most income comes from off the farm. Over 13,000 of Florida's 34,000 farm operators spent over 200 days off the farm in 1997, while over 19,000 reported that their principal occupation was not farming [USDA NASS, *1997 Census of Agriculture*, Table 1].

Furthermore, not all rural residents can move at will, even if they wanted to. This is particularly true of certain agribusinesses because assets are fixed. Hypercommunications infrastructure must come to the rural customers if they are to have access to high-speed networks.

5.2.2 Infrastructure Dimensions

Just as rural has more than one conceptualization, so too does infrastructure. Rural Florida's communications infrastructure is often erroneously equated with the PSTN (Public Switched Telephone Network) operated by the monopoly ILEC (Incumbent Local Exchange Carrier). That same wireline infrastructure may be unbundled and resold or used to interconnected to networks controlled by IXCs, ALECs, ISPs, or wireless carriers. Infrastructure is the physical plant through which a service provider offers access to the hypercommunication network and value added services to subscribers. Next, the dimensions of infrastructure are considered on several levels.

Some authors (Hubert, 1996) use the term infostructure to dramatize the difference between "information communications infrastructure from more traditional national systems such as: transportation, power generation and resources, natural resources, education, water, sewer, health care, housing, and the postal service." [Hubert, 1996, p. 21] Hubert defines infostructure (what this study calls hypercommunications infrastructure) as:

> The combination of all the elements of a country's information communications infrastructure, which would include the following capabilities related to the creation, capture, storage, processing, transmission, and reception of all forms of information: transmission facilities, information services (cable, fiber, wireless) gateways/utilities, switching, terminal equipment/receivers, network management software/systems, data storage devices, broadcasting equipment, computers and data processing equipment, software operating systems and utilities, financial settlement systems, data capture devices, security/validation systems, applications software, and data/content libraries. [Hubert, 1996, pp. 91-92]

While part of a modern business' infrastructure consists of local level devices it owns (CPE), an agribusiness connects to the outside world using a carrier's access infrastructure. Indeed, the CPE the agribusiness buys depends on the access infrastructure. There is no point in purchasing fiber optic transceivers if analog POTS lines are the only wireline connection in an area.

Chapter 4 discussed (in section 4.3) the differences among copper, coaxial, and fiber optic wireline conduit as well as the frequency spectra over which wireless communications paths are beamed. Chapter 4 also explained the differences between the QOS reference model (access level, local level, and transport level) with the OSI layers of data communication. It becomes important to capsulize that material so that the most important incentives and barriers to infrastructure development can be discussed free from technical detail.

Table 5-4 shows some of the main aspects of outside infrastructures that could serve agribusiness. Rows of the table feature the four general hypercommunication sub-markets from Chapter 4 along with essential high-speed technologies used to provide wireline and wireless access to the appropriate communication network. Since regulatory markets are defined somewhat differently (and these affect infrastructure directly), their influence is shown in the first column.

Table 5-4: Infrastructure by service type and transmission technology.

Service (text location)	Local access	Transport
Wireline		
POTS (4.6)	Copper loops (4.3.1, 4.3.2, 4.6.2).	PSTN DLC-RAVs, PSTN fiber backbones
Enhanced telecommunications (4.7)	Conditioned copper loops, repeatered or DSL copper loops, or cable (4.3.2, 4.7.3).	PSTN DLC-RAVs, PSTN & dedicated fiber backbones
Private data networking (4.8)	Conditioned copper loops, repeatered copper loops (4.8.2-4.8.4).	Non-PSTN Fiber backbones.
Internet (4.9)	Copper loops and conditioned and repeatered copper loops (4.9.1).	Mainly non-PSTN fiber backbones.
Wireless		
Terrestrial mobile telephony (4.7.5)	Towers and cells.	PSTN fiber backbones
PCS, SMR, and paging (4.7.6)	Towers and cells.	Mix of wireless towers and PSTN fiber backbones
3 G terrestrial mobile (4.7.5)	Towers and cells.	Wireless towers, PSTN fiber backbone for voice calls
2-4 GHz terrestrial fixed (4.4.2)	Towers and coverage zones.	Usually WAN or Internet fiber backbones
Upperband terrestrial fixed (4.4.2)	Towers and tower collectors.	PSTN, WAN, or Internet fiber backbones.
Satellite (4.4.3)	Uplink and downlink to satellites.	Satellites and fiber backbones

A full discussion of the technical details of most of the entries in Table 5-4 is given through reference to the appropriate section of the text. Each transmission technology (wireline and wireless) and each transport and service type has its own infrastructure dimension. The extension of a hypercommunications infrastructure to rural areas is often far more complicated than the narrowly definition of Table 5-4 allows.

Alternative network structures such as CATV, ISP-ALEC, or local electric utility grids represent attractive possibilities for rural areas, but have been less well-researched by firm R&D

efforts when compared to ILEC and IXC R&D histories. Research by AT&T, Lucent, Bellcore (Telcordia), and the REA has examined almost every aspect of hypercommunications. So far, the sub-industry with the best[4] long-run R&D record of accomplishment (telephony) appears poised to gain the largest market share of a converged hypercommunications industry except that regulatory burdens on telephony are the highest as well.

Importantly, regulatory constraints on services have shaped telephone industry R&D portfolios. During the years that AT&T was prohibited from the computer business, for example, R&D in that area worldwide suffered, so great was AT&T's position. AT&T (MediaOne), BellSouth, GTE (Bell Atlantic), MCI Worldcom, and Sprint (soon to be MCI-Sprint) are five of the top Florida hypercommunications providers with roots in the telephone industry. For many years, BellSouth as an RBOC was prohibited from hardware sales in the computer communications and telephony-related CPE markets while GTE, MCI, and Sprint were not. While asymmetric regulation prevent ILECs from offering long-distance and other services, the past monopoly status of AT&T and the RBOCs enabled them to spend generously on forward-looking R&D that still yield distinct market advantages.

Table 5-5 concerns an especially important dimension of infrastructure, how economists analyze costs of infrastructure development. Currently, most economists and regulatory authorities believe that forward-looking costs are the most applicable way of analyzing infrastructure costs [FCC, 97-160, 1997]. Egan defines forward looking as:

> A descriptive term normally associated with incremental costing methodologies and techniques utilizing estimates of quantities, costs, and conditions that will prevail during a future period. It also implies costs yet to be incurred as opposed to costs previously committed. [Egan, 1996, p. 347]

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[4] Best may be optimal expenditure and investment over time, broadest scientific disciplinary base, optimal rewards to group and individual innovators, highest shareholder returns from research, or other concepts.

Table 5-5: Average Incremental Costs (AICs) of various infrastructure constructions.

Technology	Service	AIC (1996)	AIC (2000)
Current cost	POTS	$1,000	$394
	POCS (Plain Old Cable Service)	$700	NA
Narrowband ISDN	ISDN-BRI access line upgrade	$100-200	$100
	ISDN-BRI upgrade with switch placement	$300-$500	$150-$200
Dedicated Circuit	ADSL	$500-$700	ADSL, $400-$500, (FCC 99-5, 1999), splitterless, $100
FTTH	Telco DLC POTS, Future ((1998-2000)	$3,000	NA
		$1,000+	$500-$700
	Telco 2-way broadband (1996), Future (1998-2000)	$5,000+	NA
		$2,000+	$1,500
	Cable FTTH 2-way broadband (1996), Future (1998-2000)	$1,500	NA
		$1,000+	$357 (Woodrow, 1999), $800-$1000 (FCC 99-5, 1999)
Hybrid Fiber cable	POCS only	$750	Under $357 (Woodrow, 1999)
	POCS and POTS	$1,350	Under $357 (Woodrow, 1999)
Wireless			
Current AMPS	Analog Cellular	$700-$1,000	NA
PCN/PCS	AMPS-D (TDMA)	$300-500	$175-$225
Macrocell	CDMA	$350 (urban)	$150
2.4 GHz	Spread spectrum	NA	$500-$1,700
GSM	GSM	NA	$699
Microcell	TDMA, CDMA	$500	$250
Fixed wireless	MMDS (TV only)	$350-450	MMDS: $330-1,165 (20% subscriber rate for 6,000 population service area.
	LMDS (TV only)	$740-$810	
	Two-way MMDS	NA	$550-$2,400
	Two-way LMDS		$5000-$15000 per building
Satellite	DBS (TV only)	$300-800	$200-$500
	LEO		$6 billion per system

Sources: Egan (1996, pp. 318-319); FCC, 99-5, February 1999; FCC, CCB, 2000; Zaatari, 1999; USDA-NTIA, 2000.

Table 5-5 shows Egan's summary of some of these AIC (Average Incremental Costs) for deploying various infrastructures on a per subscriber basis. Alternative sources (when available) have also been posted in Table 5-15 to obtain a range of estimates, both for 1996 and for 1998-2000. All AICs shown are broad estimates of nationwide averages. In some cases, especially wireline and cable, costs in parts of Florida would be lower than the national average.

It is important to note that most of the forward-looking costs for the services listed in Table 5-5 have dropped dramatically from Egan's 1996 survey to the present according to several sources. The cost decreases in some cases have come from lower conduit prices or improved efficiency as the installed base grows. In other cases, the decrease in costs is a result of technological advances such as new multiplexing or spread spectrum technologies that allow more traffic to be carried over a single wire or radio channel.

5.2.3 Universal Service and Universal Access

Having served as the main method of business communications for decades, telephone interests have created much of the current debate about Universal Service. Importantly, the term universal service was first employed by AT&T's Theodore Vail, who has been called the father of communications marketing. That early definition of universal service meant that service would be universally provided by AT&T and was akin to interconnection. Early telephone customers could not even talk with each other because of differences in equipment and lines. AT&T created *de facto* and later *de jure* standards that would eventually apply to the entire PSTN.

Universal service (and its high-tech cousin universal access) are the next essential terms of hypercommunications policy. Indeed, the specific policy mechanisms of universal service are covered in 5.5.1 and the topic occurs throughout Chapter 5. Therefore, it needs to be defined. The 1996 TCA defines universal service as "an evolving level of telecommunications services that the FCC shall establish periodically, taking into account advances in telecommunications and information technologies and services." [1996 TCA, Title 1, Sec. A] More specifically, the statute conceived of seven policy bases of universal service as given in Table 5-6.

Table 5-6: Seven policy bases of universal service.

Basis	Purpose	Status
(1) availability of quality services at just, reasonable, and affordable rates;	Boost equity, capture positive network effects for society.	92.6 % of Florida households have telephones, up 3.9 % from 1984
(2) access to advanced telecommunications and information services to all regions of the nation;	Boost equity, capture positive network effects for society.	Still under study, FPSC states goal is 56 kbps until ILECs upgrade plants. Fewer than 40% of COs could support DSL in 9/99.
(3) access and costs in rural and high-cost areas that are reasonably comparable to that provided in urban areas;	Help prevent rural areas from becoming economically disadvantaged.	Rural rates still balanced.
(4) equitable and nondiscriminatory contribution by all telecommunications services providers	Avoid burden of regulation from falling on any single firm or sub-market.	Not met. ILECs and IXCs bear burden.
(5) specific and predictable support mechanisms;	Guarantee funding sources and uses. Calculate specific subsidy amounts.	Not met. Florida committee has just settled all issues.
(6) access to advanced telecommunications services for schools, health care, and libraries;	To improve human capital stock, epistemic value of education, save lives, save travel costs of population.	Met. Overwhelming number of Florida schools and libraries (even rural) have Internet access.
(7) such other principles as the Board and the FCC determine are in the public interest.	Allow for needed dynamic adjustment mechanisms.	Hands off Internet. New separations rules. Ruling on reciprocal compensation.

Sources: Bases from 1996 TCA. FCC, 2000; FPSC, 1999.

Local-state joint boards and the FCC were directed to "base policies for the preservation and advancement of universal service on" seven factors or bases [1996 TCA]. For each basis, the purpose and status are given. Some of the purposes behind universal service reoccur as rationales for overall government involvement in hypercommunications in 5.4 as well.

The first policy base of universal service is availability of quality services at just, reasonable, and affordable rates. The purpose is based on equity rather than directly on economics. However, if network externalities are positive, then spending on mechanisms to support the policy may bring more benefits to society than costs. There is some evidence that the policy has not been as successful as it might have been at promoting universal availability of telephone service. While 92.6 percent of Florida households have telephones, fewer than 80 percent of certain income and educational categories do [FCC, 2000; FPSC, 1999]

The second policy base is to ensure access to advanced telecommunications and information services to all regions of the nation. This is also known as universal access to underscore the fact that the goal is not restricted to analog POTS. Advanced telecommunications has been defined as 200 kbps or greater on a federal level [FCC CCB, FCC 00-290, 2000]. However, the FPSC states their goal is universal 56 kbps, but it will be as many as three years (until ILECs upgrade plants) to achieve even this base universally throughout Florida. Until 20002, 56 kbps is defined as broadband accessible in Florida [FPSC, 1999, p. 3]. Extending the definition to more advanced services is still under study by the FPSC. In September 1999, fewer than 40% of Florida COs could support DSL. However, enhanced telecommunications services are increasingly available in urban and suburban parts of Florida.

A third basis of universal service is that access and costs in rural and high-cost areas be reasonably comparable to those in urban areas. Rural rates are still balanced by FPSC regulations to ensure rough comparable. This subject is considered later as a mechanism of government involvement in 5.5 and in 5.6.2 in the context of universal access.

The fourth policy basis, equitable and nondiscriminatory contribution has probably not been met. ILECs and IXCs still bear the burden of paying support mechanisms. The incidence of the support fee on customer bills for extending universal service is such, the telcos argue, that all of it must be passed on to customers. While bills of large businesses have fallen drastically, bills for small businesses and residential accounts (especially for extremely low use customers) have risen up to thirty percent. The increase is partly attributable to the universal service fund and other charges and taxes resulting from the 1996 TCA.

Specific and predictable support mechanisms for universal service are the fifth policy base for universal service. Collected funds are subject to a variety of administrative formulas that regulators and telcos are still sorting out. Indeed, two new mechanisms have just been enacted by the FCC in the year 2000 [FCC, May 31, 2000]. However, the sixth policy base for universal service, access to advanced telecommunications services for schools, health care, and libraries; has been quite successful. An overwhelming majority of Florida schools (even in rural areas) has obtained advanced services through the Schools and Libraries program.

Finally, the 1996 TCA allows for dynamic adjustment mechanisms as needed. While the FCC has concluded that Internet traffic is jurisdictionally mixed (part local and part interstate), it has taken a hands off policy to regulation. Given the increase in low cost and even free IP telephony services, there have been calls by telcos for regulation of voice over Internet. While the FCC has ruled that Internet traffic is jurisdictionally mixed (and thus potentially subject to interstate-intrastate separations rules), the Commission has taken a hands-off approach to regulating the Internet. The FPSC and FCC have been considering numerous cases regarding reciprocal compensation, or how one carrier is paid by another for terminating calls, especially to ISPs.

According to some views (such as those of the rural communications lobby OPASTCO), deployment of infrastructure depends on the federal commitment to universal service. A recent OPASTCO study suggests that even if carriers plan to upgrade rural infrastructure, their ability to realize those plans "is largely dependent upon the universal service mechanisms enacted and the extent to which continued infrastructural upgrade is economically feasible." [Hobbs and Hobbs, 1998, p.28]

Importantly, the term universal access is used instead of universal service to signify that universal POTS telephony or even universal enhanced telecommunications services leave out some important ingredients of the infrastructure of the future. As the NTIA-RUS report in June 2000 put it:

> We urge the Federal Communications Commission to consider a definition of universal service and new funding mechanisms to ensure residents in rural areas have access to telecommunications and information services comparable to those available to residents of urban areas. [NTIA-RUS, June 2000, p. iv]

The idea here is to replace the current static definition of universal service as "both a voice grade bandwidth of 300 to 3400 Hz and a data rate of at least 28.8 kbps" [NTIA-RUS, June 2000, p.42]. The new definition, universal access would be an evolving standard that would fulfill the requirements of the 1996 TCA to support advanced services that is more in line with the policy bases given in Table 5-6. The regulatory differences between universal service and universal access (the result of convergence) are discussed further in 5.6.

Before considering the economics of how specific universal service (and other regulatory mechanisms) operate, it is important to cover the history of regulatory and infrastructure to create the base scenario for the economic analysis of the chapter.

5.3 Regulatory and Infrastructure History

Economics provides an excellent context for studying the history of infrastructure and government actions in communications. To quote Louis Schmidt in 1916:

> The agricultural economist needs to be familiar with the economic life of man in the past in order to realize and appreciate the organic nature of society. He should be historically minded if he would deal most effectively with the problems of the present.... The great problems of rural communities are human rather than merely materialistic. That is to say, they are economic, social, and educational, and cannot be understood except in light of their historical evolution. [Schmidt, 1916, p. 45]

Infrastructure development is important to agriculture because the rate at which it occurs is markedly different between rural and urban areas, as well as varying among regions of Florida. Re-regulation, taxation, and other policies are meant to speed up the development of infrastructure in markets that have been missed by the uneven pace of competition. Federal, state, and local governments have a variety of policy mechanisms designed to ensure universal service or rough parity among geographic locations in Florida. However, the regulations themselves can often lead to barriers to entry, limitations on service, and decreased competition. Public policy will influence the choices and costs many agribusinesses will face in the hypercommunications marketplace.

The history of how traditional telecommunications has converged with other sub-industries to create hypercommunications and the rural-urban infrastructure dichotomy depend on the four sub-markets presented in the last half of Chapter 4 but with a different organizational framework. However, the traditional telephony (POTS) and enhanced telecommunications infrastructure is considered first (5.3.1) because it is still Florida's widest in geographical terms, largest in dollar terms, and an important and measurable source of efficiency and coverage. Wireline access to enhanced telecommunications, private data networking, and the Internet are part of the same story. Agribusinesses still rely mainly on wireline local loops to access hypercommunication networks other than the PSTN.

The second regulatory history is of broadcast and wireless technologies (5.3.2). This segment covers a wide regulatory and historical territory, ranging from rural AM "daytimer" radio stations to international satellite networks capable of video, voice, Internet, data networking and broadcast transmission. Mobile services in this sub-market duplicate those of traditional and enhanced wireline services and interconnect to the PSTN through most of Florida. New fixed and mobile services are being introduced that can compete with wireline cable or telephone companies alike.

Before the 1996 TCA, regulation was enacted separately for wireline and wireless transmission technologies and services. Even after the TCA, ILECs are regulated differently from other telcos (ALECs and IXCs) who are regulated differently than cablecos and mobile wireless providers. The sources of these regulatory asymmetries are based on history, technology, and recent regulatory reform. Hence, after covering the wireline and wireless infrastructure and regulatory history, 5.3.3 looks at the 1996 TCA which was designed to update regulations to include the emerging reality of hypercommunications convergence.

5.3.1 Wireline Infrastructure History

No discussion of hypercommunications would be possible without a thumbnail sketch of the telephone system, as it has evolved over the last 122 years in Florida. Florida's hypercommunications infrastructure is a product of her Reconstruction days as an impoverished and remote Southern state, her unique right-of-way laws (stemming from the 1920's land boom), and her rapid growth after World War II fueled by Northern immigrants. However, the state's wireline infrastructure also includes enhanced telecommunications, private data networks, cableco networks, and Internet backbones and access methods. The result is an amazing diversity, with Yahoo! naming Miami the tenth most wired city in America in 1998[5] [Yahoo!, 1998].

Within the wireline category is a short history of new entrants including cablecos and so-called "dark fiber" providers (such as electric utilities) with existing fiber optic capacity, sometimes in rural areas. These providers have their own infrastructure economics that often allows them to supply FTTH (Fiber to the Home) or FTTN (Fiber to the Neighborhood) at less cost than telcos can. However, their existing plant (described in detail in 4.3) does not reach many rural areas and depends on each cable or electric company as to how (or whether) it has been developed. While access to the Internet and private data networks can be obtained through cableco connections, the main wireline source is still via telephony local loop.

The story of Florida's modern communications infrastructure begins after Samuel Morse's famous "What hath God wrought?" telegraph message sent to Baltimore from Washington D.C in 1844. With the first transatlantic telegram transmission in 1858, Cyrus W. Field was able to communicate to London from America[6]. That inaugural transatlantic message would predate the first transcontinental one by three years, so important was the Northeast during the introductory years of the telegraph. Only in 1861, as the Union entered the Civil War was east west communication within the United States considered vital.

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[5] By 1999, Miami had fallen to number 28 [Yahoo!, 1999]

[6] On page 566 of the *World Almanac*, 1866 is the year given for the first transatlantic cable telegraph transmission. A detailed explanation of the reason for these and many other years being given as firsts for telegraph and telephone service is available in Oslin (1992).

One reason the South suffered during and after the Civil War was her inferior telegraph system. After the War, when Western Union and later, the new Bell Telephone Co. began to expand the telecommunications infrastructure, some argue that the Reconstruction South was neglected. However, telephones were in use as early as 1878 in Jacksonville. By 1880, Florida's first telephone exchange opened there, a mere 28 months after the first CO started in New Haven, CT and four short years after the inaugural Bell-Watson conversation.

Instead of neglect, others say that the slow spread of the telephone southward was based on a marketing reality: there were too many rural, poor, and illiterate people in the Reconstruction South (especially Florida) for telephone service to be profitable [Oslin, 1992]. The few early telephone customers in Florida in 1900 had to contend with severe static and interference. At the turn of the century, the sunshine state had just over 520,000 inhabitants and but two large towns, Jacksonville with 28,000 people and Tampa with 16,000. Miami was a small town with 1,700 inhabitants and only 3 telephones. The essential role of transportation in the development of Florida's communications infrastructure as well as the agricultural settlement of the state as the 20th Century began cannot be overemphasized.

However, post-Civil War efforts at developing Florida's transportation infrastructure were stymied by many factors resulting directly and indirectly out of Reconstruction, as well as by Florida's rural, underdeveloped, backwater frontier image. One example of the difficulty the state had in developing an infrastructure can be seen by examining the Internal Improvement Fund. This fund enabled the state to finance (through bond measures) the construction of the railroad system during the 1850's. Postwar Florida's state government could not pay the bearers of these bonds in cash, and the bondholders refused land. In 1881, after federal courts were implored to force the state to sell land to satisfy bondholders, the state sold 4,000,000 acres of "swamped and overflowed" land for twenty-five cents an acre to Hamilton Disston [Patrick, 1945, p. 480]. It was then free to offer land grants to individuals desiring to make transportation improvements [Patrick, 1945, p. 87]. Therefore, it was not until the 1880's and 1890's that serious improvements to Florida's meager transportation infrastructure of the 1860's were begun.

However, even with some new railroads and roads, by 1920, Florida's rural communications infrastructure was still behind every other part of the country except for Louisiana, Georgia, and South Carolina as Figure 5-5 shows [US Census Bureau, 1924, p. 305]

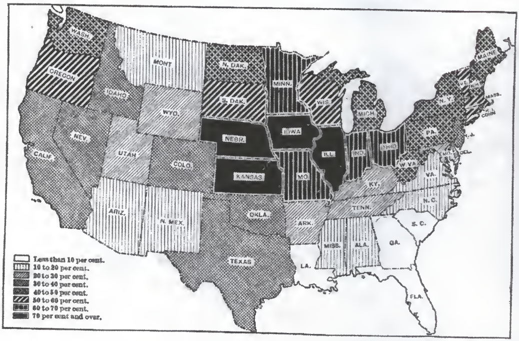

PLATE No. 271

1. PER CENT OF ALL FARMS REPORTING TELEPHONES, BY STATES: 1920.

Figure 5-5: Florida ranked at the bottom nationally in farm telephone penetration, 1920.

During the 1920's, parts of urban Florida had become a vacation mecca for wealthy northern tourists who demanded better communications. Henry Flagler launched a modern railroad to deliver tourists by train, Collins built the Dixie Highway to deliver tourists by auto, and Florida's agribusinesses required better roads and railroads to deliver their goods to market. Rather than bring a universally better communications infrastructure, the new transport structure brought about a tradition of what USWest Chairman Solomon Trujillo calls "electronic redlining". The most modern telephone plants were installed only in particular areas, with minority, rural, and poor areas left with below average services and aging equipment.

It only took a generation for the telephone to become a luxury status symbol in urban America. It would take longer to reach rural America to become a status symbol there while becoming commonplace on the urban scene. By the later years of the Great Depression, in 1938, fifty years after the telephone arrived in Florida, telephone service was either non-affordable or not available to many Floridians. While firmly established in the city, it would take programs such as the REA (Rural Electrification Administration) telephone bank, a depression-era federal agency, to establish co-operatives to serve certain rural areas.

Federal regulatory history began with the 1910 Mann-Elkins Act, the first legislation to regulate telephone rates. The Act was enforced by the ICC (Interstate Commerce Commission). By 1921, Congress passed the Willis-Graham Act allowing the ICC to administer acquisitions and mergers in the telephone business. The 1934 Communications Act turned authority over to a new agency, the FCC.

By 1948, wartime wireless breakthroughs caused the FCC to force AT&T to carry television signals at regulated rates and AT&T was powerless to stop TV network microwave networks that were separate from the PSTN. Wireless technologies resulted in the eventual competition in long-distance. Additional background to the history of wireless regulation is found in 5.3.2.

In 1949, the federal government brought the action United States vs. Western Electric based on the Truman Administration's public philosophy. The government contended that AT&T should divest itself of Western Electric (its wholly owned subsidiary) that made all business and residential telephones and virtually all telephone infrastructure equipment. The settlement of the case did not come until 1956 and was seen at the time as a victory for AT&T because AT&T's structure was left almost unchanged. By this time, Western Electric had withdrawn from making

TV, radio, and other non-telephone equipment. In the 1956 settlement, AT&T agreed to stay out of equipment markets outside of the telephone industry. However, valuable patents developed by the Bell System had to be licensed at reasonable rates to other companies according to the settlement.

In spite of anti-trust pressure from the government regarding AT&T's Western Electric subsidiary monopoly on telephony CPE, AT&T staved off all attempts to interconnect non-AT&T equipment into the telephone network. One of the earliest interconnection technologies that AT&T had to defend itself from was a plastic device called the Hush-a-Phone that snapped onto telephone sets (earpiece and mouthpiece) so that conversations would be private. Hush-a-Phones were not electronic and could not cause negative externalities to ripple through AT&T's network. Nonetheless, AT&T defended (unsuccessfully) against the use of Hush-a-Phones in FCC hearings and in court from 1948-1956.

Competition in long distance began as MCI gradually chipped away at AT&T's monopoly of the telephone transport network once the FCC mandated new microwave interconnection rules. In 1969, MCI was allowed to offer inter-city microwave transmission for subscribers, beginning a new industry of SCCs (Specialized Common Carriers). Initially SCCs offered point-to-point circuits so that calls could be placed only among subscribers to the SCC's network and not to all telephones in the world as in the PSTN.

In 1974, MCI filed suit against AT&T, charging anti-trust violations such as monopolization and failure to interconnect. A final verdict in the case was not received until 1985, when AT&T was ordered to pay MCI $120 million dollars. In addition, in 1974, the Justice Department brought a suit that sought to force AT&T to spin off local service from the Bell System.

MCI also established its own long-distance service, Execunet, in 1975. To place a long-distance call, a local number (essentially a POP) was dialed and the long-distance caller entered a series of access codes to Execunet. Then, a call could be completed to PSTN telephones in any area code Execunet served, establishing in essence a long distance call through MCI's microwave relay network instead of AT&T's transport network. AT&T brought legal action arguing that such a service was outside the point-to-point nature of SCCs and was actually a long-distance call. In 1978, after protracted appeal, AT&T and the FCC (which took AT&T's side) lost the case to MCI. Competition in long distance was established. MCI also was allowed to provide FX (Foreign Exchange) service.

The Justice Department's 1974 suit reached settlement in 1982 with the breakup of AT&T. Since over 871,000 pages of testimony, exhibits, and pleadings were made in the case, only a bare summary of the main issues can be given. The essence of the government's case was in four areas. The first area concerned the right of SCCs to interconnect to AT&T's local or transport network. A second issue was the fact that Western Electric still provided equipment for the entire Bell System so that competition in switching and other telephone network equipment was stifled. A third issue was AT&T's refusal to allow CPE (owned by customers but made by non-AT&T manufacturers) to interconnect with the PSTN. AT&T insisted that customers with such non-approved CPE use only AT&T manufactured devices to permit interconnection. Fourth, and finally, was the issue of how the SCCs and bypass carriers should compensate AT&T for completing calls that were originated and transported over non-AT&T networks.

By 1982, parts of the Justice Department's objectives in the case had been obtained in the Execunet case or were being re-tried after a 1.8 billion dollar settlement in favor of MCI in MCI's own anti-trust case. Additionally, FCC and state regulatory authorities were liberalizing CPE interconnection rules. Greene (1997) argues that neither the government nor AT&T had anything to gain by waiting years for the trial and appeals process to grind on. Therefore, the case was postponed in early 1981 to allow settlement negotiations to be made.

According to Stone (1997, p. 81) the breakup settlement consisted of AT&T agreeing to:

> . . . divest its twenty-two local operating companies and withdraw from the local-loop business. In exchange, the Justice Department agreed to let AT&T keep its manufacturing arm and retain Bell Labs, the research facility, although

> AT&T agreed to help the seven newly formed RBOCs set up Bellcore, their own research facility. Most importantly, from AT&T's perspective, many of the restrictions on AT&T contained in the 1956 consent decree were lifted. [Stone, 1997, p. 81]

The settlement would be known as the MFJ (Modified Final Judgement) and was issued at the beginning of 1984. AT&T was now allowed into the computer business and permitted to remain in the nascent wireless (cellular) telephone business. AT&T had to spin off local telephone and other local services into the RBOCs who themselves were generally prohibited from offering long distance or non-regulated services. In addition to long-distance, AT&T was allowed to operate primarily in competitive markets such as data communications, network management, etc. The RBOCs had to allow equal access to long distance and directory assistance services provided by other companies, but were permitted to hold on to the lucrative Yellow Pages.

BellSouth Corporation, the RBOC that covered much of Florida (see Figure 5-6 later in this section) was formed through the merger of two AT&T spin offs, the Southern Bell Telephone Co. and South Central Bell Telephone Co. The MFJ allowed the seven RBOCs to each remain larger than GTE, the nation's second largest telephone company before and after the breakup. RBOCs could sell or lease CPE, but not manufacture it. The future of BellSouth, GTE, Sprint, and other ILECs (Incumbent Local Exchange Carriers) was assured within Florida as well. The MFJ changed the infrastructure and regulatory structure enough that ILECs could eventually be joined by new wireline carriers, such as ALECs (Alternative Local Exchange Carriers). IXCs (Interexchange Carriers) or long distance carriers were established by the MFJ.

However, POTS and enhanced telecommunications services provided by telcos are not the only story of wireline access and regulation to be recounted. Cable and electric companies bypass the local access level of the ILECs (using their own local loop) to provide POTS, enhanced telephony, Internet, and private data networking access. It would take new legislation, the 1996 TCA (covered in 5.3.3) to allow wireline regulation and infrastructure to admit new services and new carriers into the burgeoning hypercommunications market.

The technical side of cable TV infrastructure is covered in 4.3.3. Models suggest that to compete with the cablecos, there are two steps telcos must follow to provide cable broadband services via the telco plant. First, there is infrastructure construction as covered in Table 5-5. Second, there are service deployment and price structure. Nationwide, a revenue requirement per customer per month of $42 is needed just for construction, and $51 per month for service deployment. In rural areas, the figures are $64 and $72 per month per subscriber. However, to provide rural business infrastructure alone the construction cost per subscriber per month is estimated at $41 and $73 per customer per month for service deployment [Weinhaus, *et al.*, 1995].

Discussion of specific Internet and private data networking access technologies was given in 4.8 and 4.9. Importantly, wireline access to both depends on telco, cableco, or dark fiber infrastructures. The recent infrastructure and regulatory histories regarding these newer developments will have to wait until after the wireless story is told and the 1996 TCA is used to level the playing field and stimulate competition.

5.3.2 History of Wireless Infrastructure and Regulation

The regulatory history of the wireless sub-market is based on the original broadcast services of radio and television, which are non-interactive mass communications media. It was once necessary to have a radio receiver or TV tuner to receive live or taped broadcasts. Now, audio and video communications can be transmitted over the Internet, through private data networks, through the CATV infrastructure, or be heard and seen via CD, DVD, or videodisc. However, the FCC still regulates the airwaves with some surprising new twists such as spectrum auctions.

During World War I, AT&T was put to work on projects for the Army Signal Corps. It was out of Western Electric's development of air-to-ground, ground-to-air, and air-to-air communications that interpersonal wireless communications developed in the United States. In 1920, a Catalina Island radiotelephone link was established by AT&T due to postwar copper shortages. Another wireless operator, the American Marconi Company, was nationalized and privatized during World War I, but Marconi's business plan was focused on navigation, telegraph transmission, ship-to-shore, and radio broadcasting rather than person-to-person wireless.

The regulatory history of wireless began in 1912 when federal courts ruled that the Secretary of Commerce and Labor could not refuse radio licenses to any qualified applicant. The ruling came in spite of a developing "tragedy of the common airwaves" where shared public frequencies were creating massive interference. The problem became so serious that by 1929, there would be 50 fewer radio stations on the air than in September 1927 when there had been 757) [Doll, 1996]. Not until 1938 would the 1927 total be reached again.

Herbert Hoover's intervention as Secretary of Commerce changed the radio market into a larger-scaled, closely regulated, and more profitable business than it had been in pre-regulatory days. In 1927, Hoover was able to form the FRC (Federal Radio Commission) to phase in the allocation of frequency licenses. The telephone ICC and radio FRC merged into the FCC in 1934. The FCC became in charge of wireless spectra using its newly granted licensing powers.

It was not until after World War II that it became clear that wireless (specifically microwave) transmission could compete with AT&T's transport network. Spectrum allocations made by the FCC permitted mining companies, railroads, the oil and gas industry, and other firms to create their own microwave networks. AT&T opposed such moves, arguing that it had sole right to transport voice communication over microwave links. However in 1959, the FCC agreed to permit private microwave networks as long as they were not interconnected with the PSTN, opening the door to limited competition with AT&T in two-way voice communications.

By the late 1960's, digital microwave transmission became technically possible, bringing new pressure on AT&T's monopoly over the telephone transport system through which long-distance calls traveled. Changes in telecommunications transport cost economics and large customer bypassing were two policy issues that directly flowed from the rapid expansion in digital microwave technologies.

First, the availability of microwave changed the economics of telephone transport from its traditional natural monopoly footing. Support for this idea came as early as 1975 when

> . . . economist Leonard Waverman argued ... the advent of microwave as a long-distance transmission medium dramatically altered the (telephone) industry's economics, so that the natural-monopoly justification no longer existed as it had when open wire pairs were the principal medium for intercity wire traffic, which was the case until the 1940's. Accordingly, he urged in an influential paper [Waverman, 1975], increased competition was in the national interest. [Stone, 1997, p.139]

Second, the availability of microwave transport in support of bypass carriers threatened to fragment the telephone market and wreak serious consequences on small local customers and local independent telcos.

> . . . At the time of the (AT&T) breakup the fear . . . that microwave would allow large business customers to bypass the local loop was widespread. . . . Lower local rates for large customers and higher access charges from long-distance companies to local companies were conceived as the most effective response to the threat, which would inexorably take its toll on the local operating companies. [Stone, 1997, p. 141]

There were two kinds of bypass involved: facility and service. With facility bypass, users built a microwave link or leased a line from a bypass vendor to connect the user directly to a long-distance location. Service bypass involves users purchasing private lines from the local operating company to reach a bypass carrier's POP [Stone, 1997, p.142]

As was mentioned in 5.3.1, AT&T's breakup came because bypass carriers (such as MCI and Sprint) argued successfully that the economics of wireless transport had changed enough that AT&T's natural monopoly was worth protection. The first case of a company other than AT&T being allowed to interconnect with the PSTN came with the 1968 Carterfone case. Courts held that wireless Carterfones (predecessors of SMR) could be interconnected directly to the PSTN. Carterfone operated radiophone equipment mainly for use as a two-way dispatch system in the oil and gas industry, but operators could connect remote callers to the PSTN as well. AT&T bitterly fought Carterfone, but was forced to allow direct PSTN connection of other kinds of CPE (including computers and customer-owned microwave systems) due the precedent set by the monopoly's loss of the Carterfone case. AT&T retained the exclusive right to supply control devices to allow customers' computers access to the telephone network for data calls and sessions.

Another wireless area where AT&T faced challenges was in satellite communications, which it lost control of with the formation of Comsat (the Communications Satellite Corporation) in the 1962 Communications Satellite Act [Stone, 1997, pp. 53-57]. The FCC had jurisdiction over new private satellite firms who were allowed to provide long-lease service but not connect to PSTN due to the international Intelsat treaty. Much later, fiber optics (as a substitute technology to satellite transport) changed the equation again. By 1997, FCC endorsed elimination of Intelsat interconnection restrictions [Stone, 1997, p.125].

Recent developments in wireless infrastructure are noteworthy for two reasons. First, the FCC has used economic theory to auction previously unallocated radio and microwave frequencies. This action has increased available spectra, making a variety of new services such as broadband PCS, digital cellular, and a variety of upperband services such as MMDS, LMDS, and DEMS possible. Spectral auctioning was proposed first in the early days of radio but was rejected. Professor Coase's 1959 article about the FCC was the first of many arguments used to show that auctions would be more efficient solutions than licensing alone [Coase, 1959]. The advice began to be taken with digital PCS auctions in the 1990's.

However, many of the newly auctioned frequencies[7] are silent as new technologies and the wireless infrastructure needed to transmit at specialized wavelengths are deployed. Carriers are investing billions of dollars in tower construction to support cellular, PCS, GSM, and fixed wireless technologies that were covered in 4.4.2. While wireless access and transport offer great promise for rural communications needs, an infrastructure is still required, though in many cases wireless infrastructures may be built more cheaply than in the wireline case. Satellite communications, because it requires expensive launches of possibly large constellations of satellites, is currently more expensive than terrestrial wireless or wireline infrastructures as evidenced by the recent bankruptcy of the massive Iridium project.

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[7] See Figures 4-30, 4-32 and 4-33 in 4.4.1 for an enumeration of frequencies.

Finally, the FCC also regulates broadcast stations including local rural radio stations. Local radio stations contribute substantially to their communities in financial and non-financial ways:

> Much of what they do goes unnoticed outside the community and may not always be appreciated within the community--- until the station goes silent or is moved out.
>
> In many small towns, it is only the local radio station that carries the fact that a friend has passed on, or that a neighbor or relative has had a new baby, or the a neighbor's barn burned, or that the county or city board is planning an increase in property taxes. These stations are the vehicles that carry urgent pleas for a blood donation to help save a local youngster's life, that the high school band needs a donation to march in the President's inaugural parade, that the school system is deficient in a vital but non-budgeted area. [Doll, 1996, p. 232]

However, a criticism of the FCC regarding the non-metro radio market is that the FCC has caused it to be overbuilt [Doll, 1996, p. 237].

It is unclear how the convergence of web broadcasting and new low power FM, HDTV, and spread spectrum technologies will change broadcasting. Just as ILECs, IXCs, RBOCs, and cableco offerings caused an uneven playing field to develop in wireline regulation, so too have mobile, fixed terrestrial, and satellite systems created regulatory inefficiencies in the wireless area. By the mid-1990's, it was plain that regulations could not keep up with the new services and technologies in the multi-faceted communications markets. As the future of convergence became more likely, there was enormous political pressure to replace the 1934 Communications Act with a regulatory framework capable of dealing with the communications infrastructure of the information economy.

5.3.3 Regulatory Pseudo-Convergence: The 1996 TCA

The need for unified legislation to replace the hodgepodge of regulations that applied to different services (from POTS to the Internet) and to different providers (from wireline RBOCs to wireless cablecos) became apparent by the early to mid 1990's. Regulation or the lack thereof is especially important in any analysis of sub-markets in the pre-converged hypercommunications sector. In studying the history of hypercommunications, it becomes clear that the regulatory environment depends closely on how markets define technologies and services. Yet, market definitions themselves depend on regulation. This dual relationship makes it hard for agribusinesses (used to a century's worth of thinking about communications as being provided by their monopoly ILEC) to get used to two important cost-cutting ideas about convergence that will simultaneously increase communication.

The first important idea about convergence (that the office telephone and computer are converging into one device) may be hard for some agribusinesses to imagine, since device-device convergence is in the early adoption stage. Second, perhaps easier to understand, and already available (thanks to competitive convergence and regulatory convergence) is the ability for an agribusiness to connect to two or more communication networks using one connection and one carrier. Adoption of the second idea requires accepting the idea that the hypercommunications marketplace will not be monopoly-controlled, even if the telecommunications marketplace was. However because of technological change, this idea was a theoretical possibility before 1996, but it only became possible with the passage of state and federal de-regulation legislation.

Recall from section 4.1 that there are more than two dimensions to convergence. However, device-device convergence, market convergence, and regulatory convergence are infrastructure-related. While device-device convergence stems from the local infrastructure owned by the agribusiness including CPE (Customer Premise Equipment), DCE (Data Communications Equipment), and DTE (Data Terminal Equipment), the other two convergences depend on outside infrastructure. Regulation is designed to bring infrastructure to rural areas so that high-speed hypercommunications will be both accessible and inexpensive. A fringe benefit of deregulation is new competition from firms previously in separate sub-markets now that multiple infrastructures (wireline telecommunications, cableco, fixed wireless, mobile wireless, and dark fiber) are available. However, since nothing prevented AT&T from buying the cable companies MediaOne and TCI, while continuing to offering long-distance and both fixed and mobile wireless services, market convergence might mean fewer providers.

The 1996 TCA (Telecommunications Act, Public Law 104-104) was signed by President Bill Clinton on February 8, 1996 [Thomas, 1998]. The exact date is important because time has sped up in the Information Age. Compressed time makes it more important strategically for regulators and industry alike to keep up with competitors, new technologies, and new services. Florida passed its own state deregulation bill in 1995, before the federal 1996 TCA went into effect.

The U.S. Senate had passed its version of the TCA (S. 652) by a vote of 81-18 on June 15, 1995, while the House passed its telecommunications measure (H.R. 1555) on October 15, 1995 [Thomas, 1998]. Though enaction had been expected during 1995, powerful interests successfully lobbied the House-Senate Conference Committee and the White House to delay the bills, knowing the Clinton administration and Congress both were expecting a tough election battle in 1996. W.T. Stanbury's 1996 chronology of US press accounts quotes the October 16, 1995 *Business Week* as saying:

> Delay gives more time for regrouping by the White House --- which has threatened a veto over cable deregulation, media concentration, and the terms under which the Bells can get into long distance. Other bill opponents include several major consumer organizations. The longer passage takes, the more leverage critics will have to extract concessions. [Stanbury, 1996, p. 23]

Some critics alleged that the legislative playing field had been tainted by campaign contributions and while the field was not completely level, contributions from each special interest category may have tended to offset one another. Perhaps no solution could balance the needs of a diverse set of local telephone companies (ILECs, ALECs, and RBOCs), long-distance telephone companies (IXCs), cable TV providers, software makers like Microsoft, and data and enhanced telecommunication CPE and DCE manufacturers. A host of (at the time) smaller players rounded out the list of affected parties. These included satellite carriers, cellular telephone companies, newspapers, radio and TV stations, educational institutions, ISPs, microwave carriers, and other firms who had begun to gobble up new wireless frequencies at FCC auctions.

The historical local telephone monopolies (ILECs in general and RBOCs in particular) had the most to gain and lose. The MFJ had prohibited them from the long-distance business and imposed a cumbersome patchwork of LATAs that affected dedicated point-to-point and circuit-switched connections sold for private data network use as well. Furthermore, ILEC responsibilities as carrier of last resort and the decisions they made concerning rural and urban infrastructure were at stake. Also endangered was the enormous capital investment on their own access and transport networks that ILECs would now be expected to allow new competitors called CLECs (Competitive Local Exchange Carriers)[8] to interconnect with. Under the TCA, these former monopolies would still have to provide universal service to any business or residential customer.

Florida ILECs (shown in Figure 5-6) included the giant RBOC BellSouth along the East Coast and certain inland locations through the state, GTE in the Tampa Bay area, and Sprint. Sprint's Florida territories are products of the Centel and United telco acquisitions mainly in Southeast Florida and the Tallahassee area.

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[8] In Florida, CLECs are known as ALECs (Alternative Local Exchange Carriers).

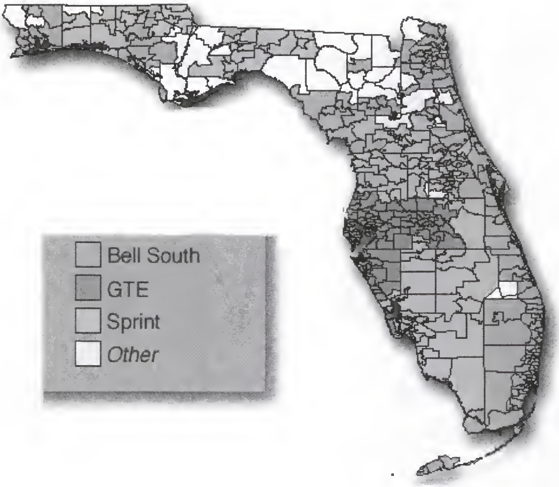

Figure 5-6: Florida ILEC service territories.

Certain rents, regulatory obligations and credits, special taxes, and assessments flowed to the ILEC in each part of Florida before the TCA because of existing state and federal legislation and FPSC actions. After the TCA, it was left to a combination of the market, and federal and state regulators as to what each ILEC would be required to do to furnish "universal service" to customers. In 1996, BellSouth, GTE, and Sprint had 59, 21, and 18 percent respectively of local access lines in Florida[9] [Florida Statistical Abstract, 1997, Table 14.60, p.435].

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[9] Further details about providers are furnished in 7.1.

The lightest area in the map shows (denoted as other in the key to Figure 5-6) shows the smaller independent ILECs of Florida. Independent ILECs are small companies that had competed against the former Bell System in an earlier age of communications deregulation (before the 1934). When the present regulatory era began with the 1934 Communications Act (the organic statute of the 1996 TCA), independents[10] were permitted to continue serving their markets. Many of those such as Alltel's North Central Florida territory were cobbled together when an existing telecommunications company purchased an existing ILEC. Others were rural telephone co-operatives.

According to RBOC U.S. West (now Qwest) Communications president Solomon Trujillo, ILECs have been trapped into an unfair and discriminatory bind by the 1996 TCA. Specifically the TCA did three things to limit RBOC operations. First, the TCA has deregulated the lucrative local line business while allowing competitors (ALECs) full right of interconnection to ILEC access and transport networks. Secondly, the TCA also mandates that ILECs (especially RBOCs) not do business in certain hypercommunications segments such as interstate long-distance.

Third, ILECs are carriers of last resort (covered further in 5.5.3), meaning they must provide service to high-cost hard-to-serve areas although infrastructure competitors do not have the same obligations. For example, cable TV rates were deregulated, but cablecos are subject to state regulation as ALECs if they provide local telephone service. Data communication, traditionally divided into basic and enhanced categories, saw the continuation of certain basic tariffs, while online services such as ISPs and OSPs were generally free from regulation. Other aspects of the TCA were discussed (along with universal service) in 5.2.3 and will be revisited elsewhere in Chapter 5.

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[10] Rose provides a short, but excellent history of universal service from the standpoint of the small independent rural telephone carrier [Rose, 1998]

5.4 Rationales for Government Involvement

The next three sections consider rationales (5.4), mechanisms (5.5), and the evolving economics of government involvement (5.6) in converged hypercommunications. Although seven policy bases for universal service (discussed when defining the term in 5.2.3) are important rationales for government involvement, there are broader rationales. As Alan Stone writes, the rationale for government involvement in hypercommunications has moved into an era of privatization and de-regulation. However, government will still need to play a role:

> Rejecting public ownership, however, does not mean that government should play *no* role in shaping market structure or behavior. . . . A historical view of (telecommunications) shows that the relationships between government intervention and market structure are complex and that the appropriate relationship has varied over time. At times when technology is advancing slowly, the service is homogenous (POTS), and there are clear scale economies, monopoly subject to regulation has led to excellent performance. [Stone, 1997, pp. ix-x]

Indeed, there are some areas where new communications media and deregulated services have led to the need for new kinds of government oversight. The FBI has dedicated resources to Internet security after recent viruses shut down millions of computers worldwide that used Microsoft's Outlook e-mail program. Slamming (the involuntary changing of local and long-distance telephone companies) and cramming (the appearance of unordered services on telephone bills) are the subject of new efforts by the FPSC.

There are four main rationales (and a host of minor ones) used to justify government involvement in hypercommunications. Social and economic goals (or a combination of both) support each rationale. Some of the rationales for government involvement in hypercommunications are simply extensions of the regulatory philosophies that historically governed the telephone, broadcasting, and cable TV industries. Other rationales are tailored to the new policy issues created by changes due to convergence and cyber communications.

5.4.1 The Natural Monopoly Rationale

The first rationale may be traced directly to the argument that since the telephone network is a natural monopoly, it is socially and economically desirable for government to regulate it. Similar reasoning is sometimes applied to hypercommunication sub-markets or providers of access to hypercommunication networks. However, the focus on the traditional telephone network as a natural monopoly often misses important economic changes that have come because of new technologies, new services, and new kinds of networks.[11]

Monopoly results in pricing where marginal revenue equals marginal cost leading to an inefficient undersupply at higher prices than would result under competition. Gould and Ferguson mention that natural monopoly exists when:

> the minimum average cost of production occurs at a rate of output more than sufficient to supply the entire market at a price covering full cost.... The term 'natural' monopoly simply implies that the 'natural' result of market forces is the development of monopoly organization. [Gould and Ferguson, 1980, p. 248]

Figure 5-7 depicts the representative demand and cost that would face a natural monopoly. The monopolist would offer Q_{NM} to the market at P_2, while a competitive outcome would be more output (Q^*) at a lower price P_1.

Under natural monopoly, fixed costs represent an enormous proportion of total costs. Therefore, a new entrant could offer Q_1 at price P_3, or a much smaller quantity for a far higher price. At first glance, Q_1 might appear to be a ridiculously small amount in comparison to Q^*. However, the difference is deliberately sizable to illustrate three important points regarding telephone networks and natural monopoly. First, the telephone network must be built for peak use so that it is important to realize that the demand illustrated in Figure 5-7 is a static representation of demand at a given time period. The uncertainty surrounding demand at peak times leads the network to be built to accommodate peak demand.

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[11] If necessary, several prior chapters should be consulted for review. Chapter 2 makes the case that communications networks have technical and economic implications on the information economy that caused the converged hypercommunication network to originate. Chapter 3 should be consulted to review how the technical characteristics and economic fundamentals of the telephone and data networks differ. Chapter 4 enumerates specific hypercommunications services and technologies and considers the separate pre-convergent markets along with the likely post-convergent marketplace.

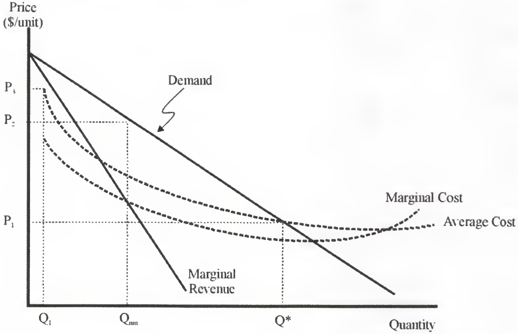

Figure 5-7: In a "natural" monopoly, average cost falls through the whole range of output.

Secondly, the units represented in Figure 5-7 are also important. On a per subscriber basis, some have argued:

> …the telephone industry is one which is sometimes pointed out as being operated under conditions of increasing costs as the size of plant increases. It is said that the cost per subscriber in a system of 10,000 subscribers is greater than in one of 1,000. The reason given is that the number of possible connections increases in a geometric ratio. [Koontz and Gable, 1956, p. 209]

Per call-minute-mile is a better unit of analysis than per subscriber as Koontz and Gable continue:

> …if the service given is actually taken into account, the telephone industry still seems to be one in which costs decrease with increasing size. While the cost per *subscriber* may increase, the cost per possible call or per call-mile-minute would seem to decrease. [Koontz and Gable, 1956, p. 209, fn. 40]

Therefore, the units of analysis have great bearing on the definition of natural monopoly.

The applicability of natural monopoly to hypercommunications access and transport is substantially different from application to the telephone network because network effects and network technologies have changed since the days of the Bell System. The technical changes that have occurred since computer networks were developed and sophisticated OR network management algorithms came on the scene may indicate that natural monopoly theory no longer applies to communication networks. Instead of a single PSTN and wireline infrastructure, new analyses of natural monopoly must consider a converging hypercommunications market in which former telephone, electricity, and cable TV monopolies compete with new entrants in multi-platform voice, data, and video communications. Until complete convergence occurs, multiple sub-markets are likely to result in competition among multi-product firms. However, there is the possibility that multilateral rivalry in multiple local markets combined with mergers and acquisitions could result in a new mega-natural monopoly.

Baumol (1997), Baumol and Blinder (1991, pp. 657-672), and Jamison (1997) each extend natural monopoly theory to multi-product firms with regard to single and multiple product markets. Jamison rigorously shows that "firms that produce products that the monopoly does not can produce some of the monopoly's products and have economies of joint production in doing so." [Jamison, 1997, p. 2] Hence, a given firm is a natural monopoly "if and only if its production economies are greater than the economies these firms can offer." [Jamison, 1997, p.2]

Additionally, regulatory costs and cost savings from single vendor providers of multiple services may not accurately reflect market prices according to Jamison. However, just as measurement difficulties led standard utility regulators to resort to Ramsey pricing and fully distributed costs [Baumol and Blinder, 1991, p. 661-664]. as proxies for per product marginal cost, the mega-natural monopolist's costs will be hard to calculate. Jamison admits as much by stating that testing for such mega-natural monopolies could be impossible due to the vast number of possible outcomes with multilateral rivalry and unstable technologies [Jamison, 1997, p. 9]

Historically, just as with its definition of universal service, AT&T was able to use its own definition of natural monopoly. As Stone puts it:

> After the turn of the century, progressivism, one of the tenets of which was firm government control over large business enterprise, had become the dominant public philosophy. One of the critical moves that AT&T undertook . . . was to seize upon progressive sentiment and turn it to the Bell system's advantage. To do this, AT&T first embraced the theory of natural monopoly that had become fashionable in academic circles at the turn of the century. Although today an industry is considered a natural monopoly if production is done most efficiently by a single firm as output increases, the term had a somewhat different meaning in the Progressive Era. Based on the wave of bankruptcies and deteriorated service that had occurred in the traditional public service industries when multiple franchises were granted, the earlier view held that service to the public is best undertaken by a single franchisee or 'natural monopoly'. It is important to note the distinction between that conception and the later economic one. Better and more comprehensive service based on empirical observation is different from a theoretical conception that purports to predict what is most efficient. AT&T sought to clothe itself in the older natural-monopoly conception, the better to portray itself as the bearer of the public interest. [Stone, 1997, p.30]

It is the sub-additive cost-technology relationship that modern economics recognizes as natural monopoly. However as Chapter 2 and Chapter 3 show, rapid changes brought on by the replacement of the telephone network's engineering-based model with computer-OR hypercommunication network models have created a new economic theory of natural monopoly. Therefore, to diagnose natural monopoly now, costs must be forward-looking and based on multilateral rivalry, structural changes, and other costs of "weightless economics" to diagnose natural monopoly now [Kwah, 1996, 1997]. Economides found that "the appropriate measure of cost (maximizing allocative, productive, and dynamic efficiency) is forward-looking economic cost and not the historical, accounting, or embedded cost of the incumbent's network." [Economides, 1998, p. 1] The recognition of this fact is responsible for the use of forward-looking cost models like the HPCM by regulatory agencies today [Bush, *et al.*, 1998]

While the balance of evidence indicates that traditionally defined natural monopolies are dead in modern communications, some attempts have been made to argue that transport level costs of fiber optic hardware and conduit have resulted in natural monopoly's resurrection. Stanbury notes:

> Technological change and economics, according to Huber *et al.* (1992), have (1) 're-created' the natural monopoly in interexchange (long-distance) telecommunications due to the economics of fiber-optic cables (high fixed costs and almost zero marginal costs), and (2) begun to make competition in local services feasible, largely due to cellular and radio technology, but also by converting cable-TV systems into LECs. The Huber *et al.* conclusion re: natural monopoly may hold in relation to transmission costs, but these costs are a modest fraction of all variable costs of long-distance service. Other evidence filed with the FCC indicates that MCI's total variable costs are less than AT&T's. This contradicts Hubert *et al.* On the matter of emerging competition in the local telephony, Huber *et al.* are correct, although their conclusion that there is no bottleneck or essential facilities, controlled by the telcos can be challenged . . . [Stanbury, 1996, p.152]

Once actual costs of fiber began to fall in the late 1990's, this idea of a resurrected natural monopoly became even less convincing.

However, as Baumol and Blinder argue: "What matters is the size of a single firm relative to the market." [Baumol and Blinder, 1991, p. 579] A natural monopoly may be a national telephone system or a local exchange if a single firm can produce the entire output at a lower cost than under competition. This point may have special bearing on underserved rural areas.

Two additional reasons support the contention that the traditional POTS PSTN was a natural monopoly due to inherent technical and engineering reasons. First, the traditional POTS PSTN was part of a larger telephone connecting system that included physical lines and poles to telephone terminals as well as systemwide indirect costs such as research and development. The enormous fixed and indirect costs (invested on a sunk basis) discouraged entry, effectively prohibiting competition. Costs of maintaining the local loop, telephone wires and plant, machinery, equipment, and research and development were so high that only a single firm (a natural monopoly) could operate.

Second, under past technology, local competition was physically unworkable in addition to being inefficient. Historical photographs show parallel telephone lines of competing telephone companies straining poles in places such as New York City. Subscribers had to have different telephones and multiple access lines in order to receive calls from customers of every telephone company. The access and transport networks from switches down to wires on telephone poles were all duplicated [Oslin, 1992]. According to these arguments, natural monopoly is based on technical factors that result in system, scale, or scope economies.

The recent consensus is that there are three general markets within the telephone system, tending to reduce system, scale, and scope economies. First, there is a market offering access to the telephone network, second a market for switching calls between parts of the network, and third a market for intermediate transport of calls between nodes. Often, economic analyses of the telephone network have failed to recognize these complementary yet separable features of the telephone system because the traditional network architecture was part of a monopolistic telephone system that was considered a natural monopoly. The recent view of the telephone business as a set of hierarchical networks has evolved from a system orientation because of deregulation and technological change. These three markets (especially access) are involved in the hypercommunications market for voice, enhanced telecommunications, private data networking, and the Internet as well.

After an early competitive period, AT&T (named the Bell System after the telephone connecting system it owned) had monopolistic control of all three parts of the U.S. telephone market (access, switching, and transport) as well as owning all telephones.[12] This control was partly based on a network engineering foundation. "The primary idea was that since the telcom system had to be as large and comprehensive as possible in the geographical sense, its technical integration should be based on some kind of central coordination." [Verhoest, 1998, p. 4] Each level of the network was considered part of an overall connecting system that could break down (or lead to injury to equipment or workmen) if varying technical standards or non-standard equipment was used. It was thought that the only possible way to ensure system economies was to have a natural monopoly telephone company.

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[12] For the moment, the fact that GTE and other ILECs had their own monopoly territories in Florida is left out of the analysis. In the traditional POTS PSTN, customers could choose only one ILEC or local telephone monopoly. In many parts of Florida, the Bell System refused to extend service to high-cost rural areas so those places were served by small "independent" telephone monopolies. At most, the "independents" owned a few nodes in an enormous national connecting system that was still dominated by AT&T [Russel, 1964, p. 336]

Others argued that the reason the "natural" monopoly label was attached to the traditional POTS PSTN era came when AT&T's anti-competitive market conduct combined with successful lobbying and the "capture" of the FCC and various state regulatory authorities. AT&T "slashed rates...bought competitors out, and tried to dent financing and equipment to others.... An independent local phone company that was refused interconnection was cut off from the entire country." [Mansfield and Behravesh, 1990, p. 395] AT&T itself worked out the Kingsbury agreement with the federal government in 1914 to guard against anti-trust action.

AT&T aggressively tried to prohibit competition during its entire history while venturing into telegraph, radio, television, and other businesses, retreating only when challenged in the courts. AT&T's massive research and engineering budget was spent on problems far broader than the telephone "system", including radio communication, television, development of cellular and other forms of wireless telephony, computers, and other interests. Under this system, politics, regulation, and predatory practices resulted in a technically inefficient telephone network run by AT&T.

It is also suggested that even if historically the telephone system or individual sub-networks were natural monopolies, new technology and deregulation have lowered costs and increased innovation making such a structure impossible. However, others argue that natural monopoly has merely become more complex in an era of convergence, multilateral competition, and multi-product production [Jamison, 1997]

In reality, it is debatable whether the telephone network (or the connecting system) was indeed a natural monopoly. This point is made on several grounds, regardless of any network engineering concerns. First, the consensus is that costs have been badly measured by traditional engineering and regulatory analyses. Again, because the telephone system is a collection of technologically changing interconnected networks, "forward-looking economic cost and *not* the historical, accounting, or embedded cost" is most likely to achieve an "appropriate measure of cost (maximizing allocative, productive, and dynamic efficiency)." [Economides, 2000, p. 1]

Second, there is empirical disagreement as to whether particular parts of the network and even the entire connecting system are indeed natural monopolies. Shin and Ying (1992) found that local exchange carrier cost structures were not natural monopolies, and, surprisingly that "it is doubtful that the pre-divestiture Bell System was a natural monopoly" [Shin and Ying, 1992, p. 171]. However, Wilson and Zhou (1997) cite a number of studies that have found that such empirical results depend on the functional form of the cost function and other econometric issues.

5.4.2 Public Infrastructure Investment Rationale

A second rationale for government involvement in hypercommunications can be expressed through the argument that today's low infrastructure growth rate is tomorrow's decayed competitive position. If that argument is true, it may be possible to stimulate economic growth (or prevent economic decline) in areas with low infrastructure growth rates using government investment (or a public-private mix) to increase the infrastructure growth rate. If the policy is calibrated correctly, both government and private enterprise can expect a revenue stream capable of repaying the government with the new tax revenue generated and providing private firms a reasonable return. This rationale is used to support a mixture of social and economic goals.

According to this argument, if government investment is used to encourage infrastructure development several effects are likely. First, there is a direct effect. The direct effect may be measured solely as benefit achieved in a particular area by the use of hypercommunications by existing firms, organizations, and individuals. Efficiencies and benefits that flow to firms from using the same amount of communications but with the new infrastructure are counted here.

Secondly, there is a multiplier effect.

> The telecommunications 'multiplier effect' refers to the level of indirect economic activity created by investments in telecommunications infrastructure expansion and modernization. These indirect benefits are measured by various cost-benefit

> analyses and input-output calculations done to determine the value of infrastructure spending. While measurement methodologies sometimes differ, the indirect economic benefits that result from telecommunications infrastructure investments are among the highest measured. . . . A recent analysis in the US, for example, determined that investments in broadband telecommunications infrastructure, at current planned rates, will add US $191 billion to GNP over the next 16 years. [According to Cohen, 1992], policy reforms to accelerate infrastructure investments in broadband networks would add an additional US $321 billion in GNP growth over the same period [Hubert, 1996, p. 83]

The multiplier effect may appear in several ways. First, it comes as firms that that use hypercommunications as their main inputs such as high-tech companies, call centers, e-commerce, or electronic commerce are able to locate in the local economy. Second, the multiplier effect occurs as existing firms change their business models to take advantage of positive network effects inherent in hypercommunications. Third, the multiplier effect occurs as benefits from connected educational institutions and individuals trickle down to create a more skilled information-literate workforce and stimulate job creation from new firms. The multiplier effect also depends on a holistic, positive interaction of these three ingredients.

The first two benefits of public investment in hypercommunications infrastructure are shown in Figure 5-8. The figure shows the hypothetical economic impact (gross) over ten periods from three separate sources. The impact shown might be for a region, a town, a county, a firm, or a group of firms. The periods represented might be years, quarters, or other planning periods. The figure does not show how time compression (see 2.5.2.5) is shortening the periods over which effects may be felt as a direct result of better communications and processing power. A base of one is used so the results may be clearer in this hypothetical case.

The bottom line shows the result that would occur without an infrastructure investment. Note that over ten periods, a growth of 25% has been achieved by doing nothing. This assumption may be quite overstated, especially in locations where it is probable that a decline would occur because of the lack of infrastructure. The middle line shows the direct effect of hypercommunications infrastructure investment. Instead of assuming a constant growth rate, an increasing growth *rate* has also been assumed. At the end of ten periods, over a 75% increase in activity has been registered. Finally, the top line shows the multiplier effect. Total gross activity has almost tripled.

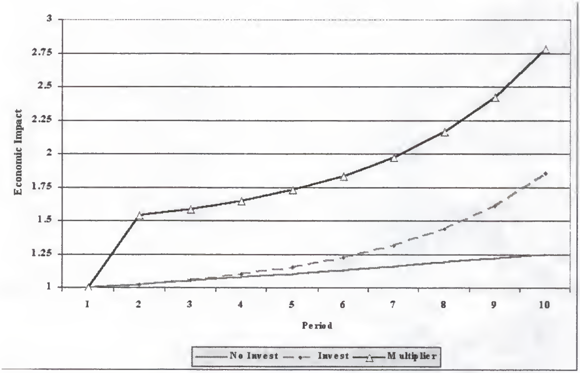

Figure 5-8: Direct and multiplier effects of public infrastructure investment.

Third, there is also a leverage effect of communications infrastructure development (not shown in Figure 5-8).

> While the economic multiplier for telecommunications infrastructure investments is substantial, the impact of these investments in the North American environment is further enhanced because they are, for the most part, privately funded. The economic and social benefits discussed can be achieved with minimal public sector funding. The 'leverage effect' refers to the level of private sector infrastructure investment that can be stimulated by public sector investment. Telecom infrastructure programs can be triggered by policy and regulatory initiatives and by tax incentives or investment credits because investment is largely provided by the private sector capital commitments. While $1 billion in government investment in highways or airports will produce $1 billion in additional infrastructure, $1 billion in government commitments in the telecommunications sector could produce $5 to $10 billion in additional infrastructure. The impact per dollar of public sector investment on job creation and other economic gains would be even more dramatic. [Hubert, 1996, p.83]

Thus, another policy exists in addition to direct transfers of tax funds to carriers serving rural or high-cost areas. Under the leverage effect, it is possible for the government to obtain more impact per dollar invested using tax incentives and other policy mechanisms as levers to loosen more private investment than would otherwise occur. The leverage effect can occur as a lead-lag relationship (with public funding establishing a skeleton infrastructure on which private enterprise constructs a body). This method was used to jump-start the Internet. Alternatively, the leverage effect may occur simultaneously with regulatory concessions and tax incentives.

To support the second rationale, many statistical studies are offered. Hubert mentions " a series of recent US studies" that highlight the "linkages between telecommunications and economics." [Hubert, 1996, p. 81] He makes seven points shown in Table 5-7.

While the results found in Hubert's review (Table 5-7) from the leverage and multiplier effects are attractive, they are not without controversy. The speed with which a national economy can grow while reducing or holding unemployment down, growing real incomes, and provide for government spending and borrowing are complex economic policy problems. Many authors of macro-communications studies automatically extrapolate national economic data on to states, counties, and precise localities.

However, there can be a tendency to extrapolate more than is warranted by enthusiastic proponents of proactive government infrastructure development policies. Hence, caution must be placed upon crucial estimates of the rate of hypercommunications penetration, concomitant growth of ideas and inventions, and the economic growth potential. This becomes important when nationally based economic growth and impact estimates are projected onto narrowly defined regions. In particular, many studies assume a base economy that is urbanized.

Table 5-7: Empirical support for the public infrastructure investment rationale.

1. Access to telecommunications infrastructure enhances productivity. Telecommunications investments since 1963 are calculated to have saved the 1991 US economy US $102.9 billion in labour and capital expenditures.

2. Telecommunications infrastructure investment creates jobs. Analysts estimate that if California increased its telecom infrastructure investments by US $500 million to US $2.3 billion per year over an 18 year period, such investments would produce, among other benefits, a total of 161,000 new jobs and US $1.2 billion in additional state or local tax revenues over the same period. (Relies on Cronin, Gold, and Lewitzky, 1992)

3. Telecommunications infrastructure investments support expert (sic, export) activity. One study found that between 1977 and 1982, US exports increased by over US $50 billion as a result of increased competitiveness induced by telecommunications infrastructure improvements.

4. Telecommunications can be an effective substitute for transportation. It is estimated that the US could save US $23 billion per year if telecommuting is only one of the ways telecommunications can replace transportation. (Relies on Little, 1991)

5. Utilization of existing health telecommunications technologies in health care applications could save US citizens US $38 billion by the year 2000. (Relies on Cronin, Gould, and Sigalou, 1994

6. Distance learning applications support dramatic gains in educational efficiency and effectiveness, and not only in the public education system. One corporate training program used distance learning to cut training costs by 90 percent. (Relies on Cohen, 1992)

7. Kiosk-based government services can dramatically improve the quality and availability of government services while reducing their cost. One California system reduced the cost of job-match services from US $150 to US $40 per person. (Relies on: Information Infrastructure Task Force, 1993.) Another California welfare program is using telecommunications to save almost 20 percent of its budget through reduced errors and staff turnover. (Relies on Hansen, 1992)

Source: Hubert, 1996, p.81.

Even when evidence from regional and local models is used, there is still a danger of over-extrapolation. The Pennsylvania Dutch country and Arizona's Navajo Reservation are both "rural" areas, but the extrapolation of results from one area to another should not be automatic. Within Florida, some areas have little traditional agribusiness, yet have timber reserves or rich fishery areas. In still other places, such as Homestead, large-scale agriculture and urbanization are on a collision course with ecological constraints and urbanization.

Finally, the rationales for universal service and universal access (already introduced in Table 5-6) include more than economic arguments about multipliers and leverage. Universal service is also a social program designed to eliminate the "digital divide" that separates information haves and have-nots [NTIA, "Falling Through the Net: Defining the Digital Divide." July 1999]. The right to get service at a "fair" price is enforced by cross-subsidizing rates or by other regulatory methods to cover the greater cost of providing service to rural areas, the elderly, or the poor. Universal access rights include the choice of carrier, carrier interconnection rights, and access to enhanced telecommunication services and the Internet. Some universal access rights are designed to ease the transition into deregulation for hypercommunications firms, while others are clearly normative attempts to add the right to high-speed Internet access to the existing rights of universal telephone service.

5.4.3 Normative or Social Rationales

A third rationale for government involvement in hypercommunications is purely based on normative or social goals. Information apartheid is a term used by Don Tapscott in 1994[13] to "splitting society into those who can communicate with the world and those who cannot," because they do not have access to the information superhighway at a "reasonable price". Social scientists argue that there are negative network effects (perhaps externalities since market prices do not reflect their costs to society) involved with increasing the penetration of hypercommunications.

However, economics is often taken as a positive (values-neutral) science capable only on analyzing costs and benefits in dollar terms designed to describe rather than proscribe the desirability of social policies such as equity or fairness [Lutz and Lux, 1988]. Other disciplines, such as rural sociology, are better disposed to rule on the normative desirability of upgrading the rural infrastructure. It is true that many Florida farmers may never use the Internet and that many in rural America would prefer to live in isolation from high technology. All an economic investigation can do is to evaluate the values-neutral positive economic pros and cons. However, just as some were suspicious of every innovation in American history from railroads and electricity to radio and TV, so now are the dangers of the Internet and hypercommunications proclaimed. Psychologists and others might argue that economics does not factor in evidence about the long-term effects on crime from watching gratuitous violence on TV.

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[13] The *Globe and Mail* (Canada), June 15, 1994, p. A10. As quoted by Shultz, 1996, p.45.

Economists might respond that the market acts on all publicly (some say privately) available information. Many economists would argue that to the degree that the psychological evidence is true, the market would react with adjustments in relative prices. However, market prices may be unable to protect human life and property based on the danger resulting from new and ubiquitous forms of information that become more available with infrastructure development. Not all network effects are positive, as the discussion of network economics in 3.7.3 recognized.

However, there are limits to the view that economics alone provides all the rationale necessary for government involvement in hypercommunications. For example, the choir of voices singing the praise of positive economics is almost silent when the discussion turns to the "child pornography" market on the Internet, or Judge Posner's famous baby sales market[14] [Landes and Posner, 1978]. Recent attempts to auction human organs, children, cadavers, human eggs, and genetic material on e-bay have been thwarted by e-bay itself. There is a growing outcry that some legislation is necessary to prevent many forms of economic activity from fraud to gambling to child pornography that can easily exist in virtual space. The legal issues of jurisdiction, harm, and the appropriate case law to apply are further thwarted by the international nature of the Internet.

In this sense, the hypercommunications industry's information content production and transmission markets may be seen as unique markets in which both a normative economic side and a positive economic side can be seen. The protection of children from pedophiles, pornography, graphic violence, and websites that secretly gather information on parents is a particularly strong rationale for government involvement. This could be because society as a whole (including economists) values children in non-economic ways as well as in economic ways. Furthermore, psychology and medicine are positive sciences also, but few economists would argue that legislation requiring reporting of child abuse by doctors and social workers (in spite of normal professional confidentiality) represents market failure due to governmental meddling.

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[14] Lutz and Lux attribute this controversial paper with preventing Judge Posner from being named to the US Supreme Court [Lutz and Lux, 1988, p. 197]

5.4.4 Other Rationales: Federal, State, and Local

The fourth rationale for government involvement is actually a set of rationales derived from many sources. Federal anti-trust statutes, the desirability of e-commerce sales taxes, the national security implications of encryption export restrictions, protection of children, and free speech issues are other areas of hypercommunications regulation. The government's multiple roles of law enforcement, preservation of national security, and encouragement of domestic commerce and international trade bring in many additional rationales for regulation such as discouraging fraud and other enemies of competitive markets. Finally, often forgotten in the debate over de-regulation is that taxation policies are regulations that affect hypercommunications more than other kinds of businesses [Cordes, Kalenkoski, and Watson, 2000]. These actions can bring possible re-regulation in the form of new taxes, laws, and policies in spite of de-regulation.

Before turning to specific mechanisms by which policy is achieved, federal, state, and local agencies with some form of involvement in hypercommunications are listed. Table 5-8 shows federal agencies involved in hypercommunications policy along with specific rationales used for involvement in some phase of hypercommunications. On the federal level, there are numerous special issue publics involved in setting policy. NARUC, the National Association of Regulatory Utility Commissions is one of many national non-governmental organizations and pressure groups that seek to affect federal policy. NECA, the National Exchange Carriers Association, administers the Universal Service Fund. Rural telephone and electric co-operatives are considered one of Washington's most powerful lobbying groups [Stockman, 1986].

Table 5-8: Federal agencies involved in hypercommunications policy.

Agency	Functions	Rationale(s) for involvement
FCC	Telephone, broadcast TV and radio, Spectral allocation. Previously regulated cable TV rates.	Monopoly regulation, multiple rationales
USDA Small Business Innovation Research (SBIR)	Encourage high-tech enterprises in rural areas.	Multiplier effect
USDA Rural Utilities Service (RUS)	Source of funds and technical advice for rural telephone co-ops. 1 Mbps access standard, distance learning, telemedicine.	Leverage effect
USDA Rural Business-Cooperative Service	Encourage and fund pilot projects for businesses in rural areas.	Multiplier and leverage effects
Department of Transportation	Improve transportation communications; regulate communications rights-of-way along federally funded roads.	Direct effect
US Department of Commerce, NTIA.	Study, monitor, and recommend policies to Congress and executive branch. Clearinghouse and grant source for e-commerce and other programs such as TOPS (Technology Opportunity Program).	Informational, statistical, and grants
US Congress	Legislative interest of House and Senate Commerce Committees.	Political, economic, social goals, appropriations
White House	Various National Information Infrastructure initiatives, bully pulpit, cheerleader.	Political, economic, and social goal setting
SLC Fund	Funding of schools and libraries for Internet access.	Multiplier effect, further educational aims
FBI	Computer crime and security, fraud, viruses, white-collar communications-related crime.	Decrease negative network externalities
U.S. Postal Service	Child pornography and mail fraud investigations.	Decrease negative network externalities
IRS	Collection of federal taxes.	Increase treasury collections
U.S. Customs Service	Assess duties and taxes on imported goods, detect and intercept illegally ordered items.	Enforce trade legislation, prevent contraband
GAO	Oversight of government purchases and sales.	Watchdog agency
U.S. Department of Education	Schools and library connections to Internet, CTC (Community Technology Centers).	Improve educational access

These groups provide legislative impetus for new rationales for regulation and re-regulation in hypercommunications. Indeed, Posner argues that "a number of standard features" of utility regulation may be the product between the regulated industry and consumer groups" [Posner, 1974, p. 351]. Most of the entries in Table 5-8 are self-descriptive. Agencies such as the FBI, IRS, and U.S. Customs Service may not regulate hypercommunications directly, but their missions provide rationales for regulations that extend into cyber space.

The TCA also was designed to allow states to continue to regulate telecommunications carriers under their own current laws, except where state statutes prevented competitive entry to the marketplace or otherwise affected FCC mandates. The TCA phrases for this requirement are given in the following passage:

> Preempts any State and local statutes, regulations, or requirements that prohibit or have the effect of prohibiting any entity from providing interstate or intrastate telecommunications services. Preserves a State's authority to impose, on a competitively neutral basis and consistent with universal service provisions, requirements necessary to preserve and advance universal service, protect the public safety and welfare, ensure the continued quality of telecommunications services, and safeguard the rights of consumers. [1996 TCA]

Florida is the nation's fourth most populous state behind California, Texas, and New York. Large and small state agencies, cognizant of Florida's especially high need for communications due to its strategic location, regulate many aspects of the state's hypercommunications industry. Florida's gigantic international and domestic tourism industry, ports, and status as a Caribbean and African trading center often involve coordinated regulatory activities of federal, state, and local agencies. Table 5-9 lists the main Florida State agencies with responsibilities in communications along with their rationale for involvement.

Most important of these is the FPSC (Florida Public Service Commission). During the Broward administration in Tallahassee, the Railway Commission (1897) "became a body with real power to exercise control over all transportation and communication companies." [Patrick, 1945, p. 100] Today, the FPSC has over 380 employees and an annual budget of just under $40 million. It is the most important state agency involved in communications, though it does not generally have jurisdiction over cable TV, wireless telephony, or the Internet.

Table 5-9: Florida State agencies involved in hypercommunications

Agency	Functions	Rationale
FPSC	Regulation and consumer protection in telephone service, electric utilities.	Regulation of monopoly, promotion of competition, universal service.
Agriculture and Consumer Services	Consumer protection in wireless and cable.	Protect consumers from unfair practices, avoid market failure
FDLE	Law-enforcement operations.	Enforce laws, avoid market failure
Health care	Telemedicine	Save lives, lower cost of access to network for telemedicine.
State purchasing	Purchase of SUNCOM and other state communications systems.	Watchdog, spend state hypercommunication dollars wisely
State legislature	Regulation and taxation	Legislate, set goals, fund programs
Universal service: Florida e-rate, LifeLine, LinkUp Programs	Independent boards appointed by Governor to study and administer universal service funds.	Economic (direct, multiplier, leverage), social
Dept. of Revenue and Taxation	Taxation. Florida gross receipts tax on telephone and other services.	Ensure collection of tax revenues.
State University System	Distance learning and extension functions.	Social and educational. Increase economic multiplier.

According to the FPSC, the "primary responsibility is to ensure that customers of regulated utility services receive adequate service at fair and reasonable rates. At the same time, the Commission is required by law to see that the regulated companies are allowed an opportunity to earn a fair return on their investments in property dedicated to providing utility service." [FPSC, July 1998, p. 16]

As in the federal case, the jurisdiction of the FPSC is limited to regulated or tariffed services of particular firms. Most regulatory attention focuses on ILECs and the POTS market, on the intrastate long-distance carriers (ILECs and IXCs), or on *tariffed* enhanced telephone services provided by ILECs. The FPSC is particularly concerned with the actions of BellSouth, the RBOC that serves much of Florida. ALECs do not require FPSC permission to set rates on services, but each carrier must register with the state and provide a price lists.

Cablecos, electric utilities, and ISPs that offer telephone or enhanced telecommunications services must register as ALECs. The Department of Agriculture and Consumer Services (DOCS) has jurisdiction over consumer complaints regarding wireless communications, pagers, and cable TV, as well as general consumer protection. The missions and jurisdictions of other state agencies shown in Table 5-9 provide similar rationales for involvement on a case-by-case basis as with the federal agencies in Table 5-8. The mechanisms of the rural telemedicine program (health care) and universal service programs (high-cost support, low-income support, and schools and libraries E-rate program) are discussed in 5.5. The other agencies mentioned in Table 5-9 do not fulfill market regulatory responsibilities and are not discussed further here. However, that should not be taken as an indication that their contributions are not important.

The regulatory players in hypercommunications are by no means limited to federal and state agencies. Many local agencies have specific regulatory functions as detailed in Table 5-10. The rationales behind the involvement of local agencies are also shown. Again, the mechanisms through which those rationales are achieved will be mentioned in 5.5, especially under taxation. Tables 5-8 through 5-10 broadly summarize the variety of functions (and some of the rationales) for government involvement in hypercommunications. However, to appreciate government involvement in hypercommunications, it is necessary to review the main mechanisms by which government is involved in hypercommunications.

Table 5-10: Local agencies involved in hypercommunications policy and infrastructure construction.

Government	Function	Rationale(s)
City executive and legislative	Award cable franchise, impose taxes	Revenue, regulate monopolies, encourage competition
County executive and legislative	Award cable franchise, impose taxes	Revenue, regulate monopolies, encourage competition
City or county transportation and right-of-way	Assign rights-of-way for all lines, poles, impose regulatory fees	Safety, aesthetics, revenue
City or county building codes	Approve all lines, poles, towers	Safety, aesthetics, revenue
County Transportation and right-of-way	Right-of-way, all lines, poles	Safety, aesthetics, revenue
City or county taxation authorities	Taxation, collection of right-of-way fees	Increase public revenue
Law Enforcement	911, computer crime	Public safety, save lives, protect property
City and County public records	Decisions regarding privacy of information about individuals on Internet	Political, social
City and County libraries	Application for SLC (Schools and Libraries Corporation) universal service funds	Educational, multiplier effects
Local planning and zoning	All lines, poles, towers, rights-of-way	Safety, aesthetics

Importantly, many of the agencies listed in Tables 5-8 through 5-10 reappear through specific mechanisms of involvement in the next section (5.5) where the economic impacts of some of the main mechanisms of government involvement are analyzed. Then, section 5.6 considers how convergence and technological change alter the economics of regulation, deregulation, and re-regulation.

5.5 Mechanisms of Government Involvement

This section does not purport to trace the precise mechanism of every federal, state, and local governmental agency's role in hypercommunications. Instead, it will highlight the economics of four main mechanisms of the TCA. This entails showing economically how the regulatory mechanisms are designed to work in theory along with problems encountered as asymmetric regulation and convergence alter the regulatory mechanisms.

5.5.1 Universal Service Programs and Mechanisms

The first mechanism to be covered in 5.5 is the universal service fund, which is actually four separate programs (some with multiple mechanisms) used to accomplish policy goals. The Universal Service Fund (USF) predates the 1996 TCA, but two new programs covering new were added by the 1996 legislation. The USF is a transfer program or an indirect regulatory fee whereby certain telecommunications carriers pay money into a fund administered by an independent agency. Funds are transferred from the carrier to the fund based upon a complicated series of revenue and traffic-based formulas. Before and after the 1996 TCA the USF has subsidized carriers that serve high-cost areas and underwritten programs designed to help low-income telephone customers pay for and establish service (LifeLine and Link Up).

The 1996 TCA expanded the USF's mission so that it now pays for rural telemedicine programs, provides discounts to schools and libraries for telephone, data networking, and Internet service in addition to the traditional low-income and high-cost programs. There has been considerable debate about what kinds of services and which carriers should receive support as well as which carriers must contribute to the fund [Kaserman and Mayo, 1997]

The 1996 TCA established the universal service mechanisms with the following language:

> Requires all carriers providing interstate telecommunications services to contribute to the preservation and advancement of universal service. Authorizes the FCC to exempt a carrier or class of carriers if their contribution would be "*de minimis*."
>
> Provides that only designated eligible carriers shall be eligible to receive specific Federal universal service support. [1996 TCA, Sec. 254]

One aspect of the TCA continues the USF as a mechanism to transfer money from urban carriers to carriers serving rural areas. Carriers who receive high-cost support directly from the fund may do so for three separate purposes connected with local loop costs. The transfers are meant to allow high-cost carriers to be subsidized by low-cost carriers, thus furthering the goal of rate equity between urban and rural areas.

Five mechanisms provide USF funds to high-cost areas. Rules regarding qualification are complicated and change from year to year. Loop costs are calculated on a NTS (Non-Traffic Sensitive Basis). During 1999, local loops with annual NTS costs of $259 or greater (just over 1.1% of all loops in the United States) were eligible for consideration to receive support from the HCL (High-cost Loop) mechanism from the USF. In 1999, under $10 million in HCL support was awarded to Florida rural-carrier certified ILECs. The LTS (Long-term support) mechanism (also designed for NTS costs) is a second area where rural-certified carriers may qualify for USF subsidies. Over $5.2 million was received by qualifying Florida rural carrier-certified ILECs in 1999 for LTS. Finally, the LSS (Local Switching Support) mechanism is a traffic-sensitive charge meant to help compensate high-cost area switching costs. In 1999, $3.6 million was paid to qualified rural-certified Florida ILECs for LSS. The total carrier-to-carrier transfer for these three high-cost programs in Florida reached $18.7 million in Florida in 1999 [FCC, CCB, 98-202, December 1999].

Two additional high-cost support mechanisms have begun in the year 2000. First, incremental support under the forward-looking cost mechanism (HCPM) for non-rural-certified carriers will allow high-cost areas served by those carriers to obtain USF monies. Second, a new IAS (Interstate Access Support) mechanism was initiated by the FCC in May 2000 to replace the indirect funding of universal service through access charges paid by IXC customers to ILECs [FCC, Sixth Report and Order in CC Docket Nos. 96-262 and 94-1, May, 31 2000]

Another universal service program[15] subsidizes carriers who provide Internet access, private data networking services, CPE, and enhanced telecommunications services to schools, libraries, and educational consortia. The following TCA language establishes the program and the discounting mechanism:

> Requires a carrier, upon receiving a bona fide request, to provide telecommunications services: (1) which are necessary for the provision of health care services in a State, including instruction relating to such services, to any public or nonprofit health care provider that serves persons who reside in rural areas in that State at rates that are reasonably comparable to those charged for similar services in urban areas in that State; and (2) for educational purposes included in the definition of universal service for elementary and secondary schools and libraries at rates that are less than the amounts charged for similar services to other parties, as necessary to ensure affordable access to and use of such services. Permits a carrier providing such service to have an amount equal to the amount of the discount treated as an offset to its obligation to contribute to the mechanisms, or receive reimbursement utilizing the support mechanisms, to preserve and advance universal service. [1996 TCA, Title I, Subtitle A]

Generally, the USF schools and libraries transfer is from the fund to the carrier that provides discounted services to the qualifying institution. A specialized e-rate program was set up to allow qualifying educational institutions to obtain discounts of 20% to 90% (based on school lunch program poverty guidelines). Qualified carriers include ILECs, ALECs, IXCs, and ISPs. Deserving institutions were identified by the SLC (Schools and Libraries Corporation), a specially created administrative entity operating under the following section that:

> Directs the FCC to establish competitively neutral rules to: (1) enhance access to advanced telecommunications and information services for all public and nonprofit elementary and secondary school classrooms, health care providers,

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[15] Technically, according to some at the FCC the USF "only supports loop costs and should not be confused with the new, more comprehensive support programs that the Commission is developing to implement the 1996 Act" [FCC CCB, December 1999, p. 3-1]. Interestingly, the FCC's own consumer information pamphlet on "Universal Service Support Mechanisms" fails to make that distinction. [See FCC CCB Consumer Information Bureau, 2000 and FCC CCB, Enforcement Division, CCb-FS014, July 1998]. Furthermore, public debates (and most importantly the charges seen on customer bills) do not distinguish among individual programs. Universal service will be used in Chapter 5 to refer to all programs, except when the term universal access is used to indicate *possible future expansions* in the definition of universal service (allowed by the 1996 TCA), but not yet made in FCC rulemaking.

> and libraries; and (2) define the circumstances under which a carrier may be required to connect its network to such public institutional telecommunications users. [1996 TCA, Title 1, Subtitle A]

This mechanism and the FCC rulemaking that followed allowed both private and public schools to benefit from the universal service e-rate plan. Rural schools were granted preferential consideration. In 2000, the FCC reported that over 90% of the nation's schools and libraries had Internet access (partly because of the program) and over 63% of U.S. classrooms are connected [NTIA-RUS, June 2000, p. 34]. The final USF program, for rural telemedicine uses a mechanism similar to the schools and libraries discount scheme. The Rural Health Care program funds are administered by USDA's Telecommunications Office.

The states have specific powers and responsibilities of their own with regard to the USF. The 1996 TCA:

> Grants States authority to adopt regulations not inconsistent with the FCC's rules. Requires all providers of intrastate telecommunications to contribute to universal service within a State in an equitable and nondiscriminatory manner, as determined by the State. Permits a State to adopt additional requirements with respect to universal service in that State as long as such requirements do not rely upon or burden Federal universal service support mechanisms. [1996 TCA, Sec. 254]

This allows specific state regulations to be established concerning universal service support. Under FCC rules, the universal service fund relies on a mix of state and federal funding from a mix of interstate and intrastate traffic. Other state regulatory policies that are relied on to a greater degree to achieve universal service goals are analyzed economically in 5.6.2.

Rates paid for universal service are established in the following language that:

> directs: (1) the FCC, within six months, to adopt rules to require that the rates charged by providers of interexchange telecommunications services to subscribers in rural and high-cost areas shall be no higher than those charged by each such provider to its subscribers in urban areas; and (2) such rules to require that a provider of interstate interexchange telecommunications services provide such services to its subscribers in each State at rates no higher than those charged to its subscribers in any other State. [1996 TCA, Sec. 254]

This passage has been responsible for an enormous amount of research, hearings, studies, and debate about precisely how to implement equitable rates. Much of the controversy surrounding the program results from charges on the bills of ILEC, ALEC, IXC, and wireless carrier customers. While not required to (and though they never did before the 1996 TCA), local and especially LD carriers began to place fixed or *ad valorem* charges for universal service on their customers' bills, increasing the controversy.

Representative Joe Scarborough (R-Florida), who represents the first congressional district of Pensacola and the western panhandle, addressed the U.S. House of Representatives on June 16, 1998, to protest the universal service fund, which he called taxation without representation. Known unofficially as the e-rate tax this charge began to appear on cellular, local, and long-distance telephone bills as: "Telecommunications Access System Act Surcharge", "Federal Universal Service Fee", "Universal Connectivity Charge", or by other names made up by the carrier. According to Rep. Scarborough, "the FCC used heavy handed tactics to try and stop phone companies from telling their consumers that a 5 percent tax had been passed onto every one of their phone bills secretly." [Congressional Record, June 16, 1998, p. H4575] Through the efforts of Scarborough and other congressional critics, together with lobbying actions, the FCC ended up dramatically reducing the scale of USF contributions in 1998, but funding rose again in 1999 and 2000 when Congress became more supportive.

The TCA prescribes which carriers were allowed to receive support from the universal service fund in section 102 of the 1996 TCA.

> Specifies that a common carrier designated as an 'eligible telecommunications carrier' shall: (1) be eligible to receive universal service support; and (2) throughout the service area for which the designation is received, offer the services that are supported by Federal universal service support mechanisms either using its own facilities or a combination of its own facilities and resale of another carrier's services, and advertise the availability of such services and the charges therefor using media of general distribution.
>
> Requires a State commission to designate such a carrier for the service area. Authorizes (in the case of an area served by a rural telephone company) or requires (in the case of all other areas) the State commission to designate more than one common carrier as an eligible carrier for a service area designated by the State commission . . . [1996 TCA, Section 102]

Especially important here is the fact that some carriers who do not pay into the USF are able to receive funds. For example, ISPs are exempt from paying into the fund, but qualified school and library ISP customers receive discounts with the difference paid from the SLC to the ISP.

Some USF programs have complicated mechanisms. Three steps may help in analyzing how the USF works in general. The first step is to concentrate on where "contributions" for the fund originate. Figure 5-9 shows the source of USF contributions by carrier type. Of the $253 million collected in *total* federal USF contributions in Florida during fiscal 1999, fully four-fifths came from IXCs or long-distance carriers. Fifteen percent came from interstate-related charges of LECs, with the balance made up of contributions from ALECs and wireless carriers. New high-cost mechanisms will change these sources considerably in fiscal 2000.

Although universal service contributions are not completely new (having originated after the 1984 breakup of AT&T), they are new to the bills of most customers [Kaserman and Mayo, 1997]. Before the 1996 TCA, carriers simply absorbed the charges as part of business expenses. This is because most carriers (of the types shown in Figure 5-9) began passing on the full cost of USF contributions to customers only after the 1996 TCA.

The charges were shifted to consumers and businesses as USF subsidies began to leave the traditional telephony industry and go to ISPs, enhanced telecommunications providers, and data networking connections and CPE. With passage of the TCA, universal service expanded from a basic telephone orientation to include discounts for more advanced services and technologies than telephony that are received by schools, libraries, and rural medical facilities. The total amount of contributions increased as well.

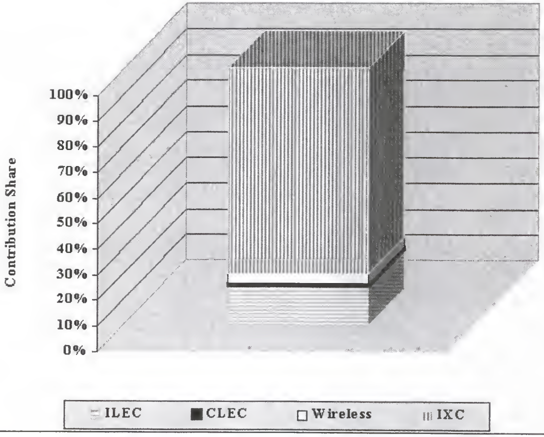

Figure 5-9: During 1999, the majority of federal USF contributions in Florida came from IXCs.

The next step in understanding the USF mechanism is to see where support dollars go. This may be looked at by program, by mechanism, in geographical terms, and by what kind of hypercommunication carriers receive funds. First, begin by considering where funds go by program. There are four universal service programs: high-cost support, low-income, rural health care, and the schools and libraries program. Each program may have more than one mechanism. Figure 5-10 shows the fund size projections for the entire United States (for the fourth quarter of 2000) for all five mechanisms of the high-cost program and for the three other programs [FCC USAC, August 2000, Appendix M5, pp. 1-2].

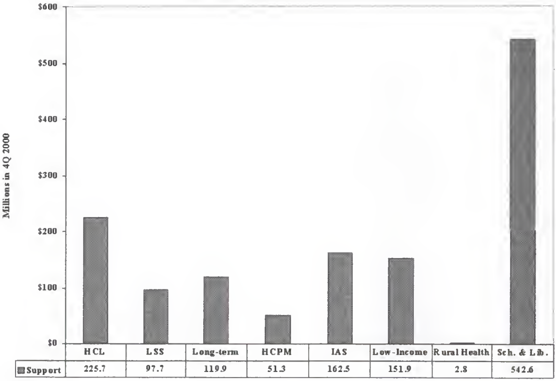

Figure 5-10: Fourth quarter 2000 federal USF program fund size projections (millions).

Roughly speaking, annual spending will be slightly less than four times the quarterly figure because of administrative expenses. Additionally, not every dollar collected will be spent in the quarter (or year) in which it was collected. USF funds for all four programs are projected to total $1.35 billion for the fourth quarter of 2000. Of this amount, $657 million will be available for high-cost support through the five mechanisms shown on the left (HCL through IAS). The schools and libraries program will be the next largest recipient with an expected $542 million. Several low-income mechanisms (Lifeline, Link-Up, incremental toll limitation, and PICC reimbursement) will represent almost $152 million. The rural telemedicine program will have $2.8 million available for the fourth quarter.

Another way of following where USF funds go is to trace the geographical and sub-market destination of each dollar collected. Figure 5-11 shows the per-dollar breakdown of USF contributions collected in Florida (and allocated to the schools and libraries) program. According to Universal Services Administrative Company data, over $105 million in total schools and libraries contributions were received from Florida sources during the July 1, 1999 through June 30, 2000 funding period [FCC CCB, Section 4, Table 4.4, p. 4-11, 2000]

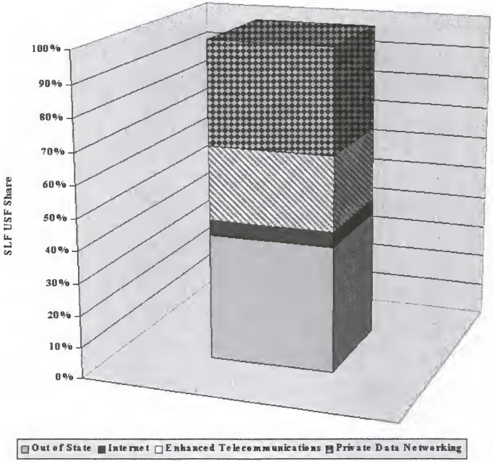

Figure 5-11: Where USF dollars flow: in Florida, the schools and libraries USF mechanism transfers funds out of telephony.

Of this total, almost forty percent of total SLC contributions went out of Florida. Of funds staying in Florida, over $5 million went to ISPs, while almost $25 million (29% of total contributions) went to enhanced telecommunications carriers (ILECs, ALECs, and IXCs). Over \$34 million (32%) was spent on private data networking and internal connections [FCC CCB, Section 4, Table 4.2b, p. 4-8]. In Florida, SLC commitments went to 813 different projects during the period.

The third step in understanding universal service is to study how particular mechanisms operate economically. For example, agribusinesses in underserved areas may be especially interested in how mechanisms in the high-cost program work. While each high-cost mechanism has a slightly different function, the general answer to this question is that all five mechanisms transfer part of the total USF charge from urban customers to rural customers.

Figure 5-12 shows how this works using data for the three high-cost program mechanisms that were in effect in 1999 (HCL, LSS, and LTS). Suppose that the right panel represents the urban local telephony market. The left panel depicts the much smaller rural local telephone market (not correctly scaled to quantity). The discussion in Chapter 6 on market boundaries will show that there are not simply two such markets, but assume that is the case for now. The example also assumes that the total is collected on access lines alone. While Figure 5-9 shows that reality contradicts this, recent reforms will make the scenario shown in Figure 5-12 more realistic.

A free market would allocate a quantity of Q_1 at price P_1 in the urban market with a far higher price of p_1 and much smaller quantity of q_1 in the rural market. USF high-cost loop contributions in Florida averaged \$0.87 per month per USF-qualified local telephone line [Eisner, FCC, 2000, Table 1.5, p.21]. Carriers (not the government) decide how customers will be charged. If the carrier figures the contribution on a percentage of total bill basis rather than a uniform monthly amount, the contribution would resemble an ad valorem tax. Hence, the supply price plus contribution would result in an upward shift from S_1 to S_2 and a steeper slope. The result would be that the urban market quantity would fall from Q_1 to Q_2 ($Q_2 < Q_1$). A further assumption is that carriers can simply pass all the USF charges onto consumers, something that has been observed in practice possibly because demand for local service is inelastic, often as low as -0.25 [Taylor, 1994, Sappington and Weisman, 1996]

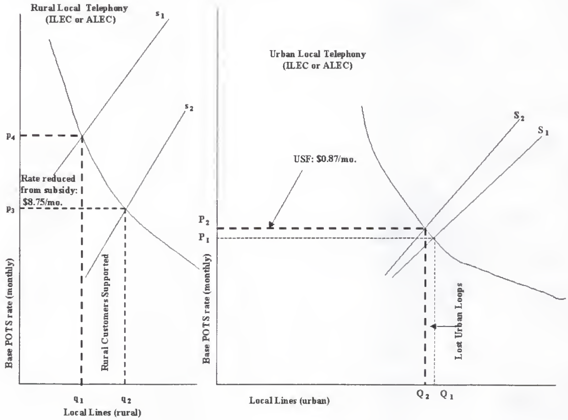

Figure 5-12: Intrastate USF loop transfer from urban LEC customers to rural-certified LEC customers.

In Florida, the entire $0.87 per loop contribution does not reach the rural market to create the changes seen on the left-hand panel. Instead, $0.14 of the USF high-cost loop support would stay in the state, with $0.72 leaving Florida to support high-cost loops in other state. Nonetheless, the large number of urban lines paying contributions is responsible for an average subsidy (USF support payment) per qualified rural-certified carrier loop of $8.75 in Florida [Eisner, FCC, 2000, Table 1.10, p.26]. as shown in Figure 5-12. The result would be a drop in price from p_1 to p_2, accompanied by a greater number of rural telephone customers with quantity rising from q_1 to q_2.

Several additional points should be noted. First, only the high-cost USF support mechanism is shown in Figure 5-12. Importantly, an additional \$0.24 is assessed on average per loop for low-income support and \$0.80 per loop for schools and libraries, along with charges of under \$0.05 per loop for rural telemedicine and \$0.13 for the telecommunications relay service. Figure 5-12 considers the direct effect of the high-cost support USF mechanism alone. Other regulatory policies (5.6.2 and 5.6.3) are used to balance rates between urban and rural subscribers of non-rural-certified carriers. The new HCPM mechanism is the first direct USF method of intra-carrier transfers for non-rural-certified ILECs that have ten times or more rural lines than rural-certified ILECs do. Analysis of such intra-carrier rate averaging is covered in 5.6.2.

The three USF high-cost support mechanisms shown in Figure 5-12 affect up to 193,000 customers of rural-certified ILECs in Florida. In some cases, the USF does not lower the rural price to the same price as the urban price in Figure 5-12, nor would that normally be the case. The FPSC sets per-carrier access rates for rural-certified carriers that are slightly higher than for non-rural-certified ILECs. USF is not the only mechanism used to work towards the goal of approximate equity between urban and rural rates. The precise rates would depend on other regulatory policies (covered in 5.6) that have several goals. Among these are general rate regulation, assurance of a fair return (or reasonable price) to the serving ILEC (whose conduit and facilities are used whether the ILEC or a competitor provides service), and approximate urban-rural rate equity.

Additionally, as was mentioned, court decisions have been made ordering future contributions to be collected from the interstate portions of carrier revenue instead of a 75-25 mix of interstate and intrastate. Hence, Figure 5-12 would have to be redrawn to show the transfer from urban IXC customers to rural local customers. While this can be done on a loop basis, long-distance carriers vary by how they charge customers for USF contributions, complicating the analysis.

Furthermore, there are second-order effects not shown in Figure 5-12. The decrease in customers in the urban telephone market because of the price increase due to the USF would be mitigated by low-income support programs. To the extent that the movement from Q_1 to Q_2 was due to a loss of low-income customers, the \$0.24 per loop low-income support USF contribution (\$0.09 of which stays in Florida) could be expected to subsidize low-income customers. The result might negate part of the urban exodus (and further increase rural service).

5.5.2 Taxation and Regulatory Charges

Taxation and regulatory charges are a second mechanism of government involvement that includes taxes, fixed charges, and proportional (ad valorem) fees. Some of these come from the 1996 TCA or other federal legislation, while others are assessed at the state and local levels. Since over 90 different taxes and regulatory fees are assessed by several hundred different jurisdictions on different services, different carriers, and different customer classes, a series of tables is needed to summarize these mechanisms. Table 5-11 gives codes to keep track of the markets, carriers, and customer categories that are subject to the regulatory fees shown in Table 5-12 and the taxes in Table 5-12. Table 5-14 is meant as an approximate summary of the various taxes and regulatory charges that can appear on communications bills for Florida agribusinesses.

The first entries in Table 5-11 (labeled M1 through M8) denote regulatory attempts at defining separate markets. In reality, the regulatory definitions of each market are more involved, but those listed represent the clearest way of separating them. Many taxes and non-tax charges affect only a particular market or markets.

The second group of entries (SP1 through SP11) represents the service providers. For most taxes, the service provider collects the tax from customers and forwards it to the appropriate government agency. For most other charges, the service provider pays the charge to the appropriate jurisdiction and has a choice as to whether absorb the charge or pass it on to customers. There is an immense burden on service providers of taxes and regulatory fees.

Nationwide, there are 10,857 jurisdictions that tax communications, with carriers required to fill out 55,748 tax forms [Cordes, Kalenkoski, and Watson, 2000]

Table 5-11: Market, provider, and customer codes.

Codes for Tables 5-12 through 5-14	Description (Text definition and discussion)
Markets	
M1	Local or intrastate POTS (4.6.1, 4.6.2)
M2	Interstate POTS (4.6.1)
M3	Local or intrastate enhanced telecommunications (4.7.3, 4.7.4)
M4	Interstate enhanced telecommunications (4.7.3, 4.7.4)
M5	Private Data Networking (4.8.2-4.8.4)
M6	Internet Access (4.9.1)
M7	Local or intrastate wireless and paging (4.4, 4.7.5, 4.7.6, 4.8.5)
M8	Interstate wireless (4.4, 4.7.5)
Carrier or Service Provider (individual carriers may serve more than one market)	
SP1	RBOCs (BellSouth)
SP2	Non-rural-certified ILECs: BellSouth, GTE, Sprint
SP3	Rural-certified ILECs: Northeast Florida Telephone Co.
SP4	ALECs
SP5	IXCs
SP6	ISPs and OSPs (4.9;)
SP7	Payphone Providers
SP8	Wireless telephone (4.7.5)
SP9	Paging (4.7.6)
SP10	Cablecos
SP11	All wireless (4.4, 4.7.5, 4.7.6, 4.8.5)
Customer Categories	
C1	Urban-suburban, large business (multi-trunk)
C2	Urban-suburban, small business (multi-line or single line)
C3	Urban-suburban residential
C4	Rural large business (multi-trunk)
C5	Rural small business (multi-line or single line)
C6	Rural residential

The third group of entries shows specific groups of customers. While each tax or charge depends on the market or provider, the customer groups (defined in POTS and enhanced telecommunications terms) are shown separately to make three points. First, many taxes and charges are paid only by business customers. Second, some taxes or charges (especially in the highly regulated telephony and enhanced telecommunications markets) will depend on how the agribusiness makes purchases from a service provider.

For example, a firm with twenty separate telephone lines (purchased on a multi-line basis) has a different tax and charge exposure than a firm that buys twenty ALEs (Access Line Equivalents) or derived lines on a trunkside basis. Finally, under old rules, rural customer groups pay the same amount that similar urban groups do in taxes and charges except that there are no city jurisdiction charges in the rural case. New regulations may allow rural and low-income customers (or all customers including businesses of smaller ILECs) to pay smaller amounts for particular charges.

Table 5-12 details non-tax financial mechanisms of government involvement in hypercommunications. Nationally, over 300 separate taxes and fees are assessed on almost 700 tax bases, so any table is a simplification [Cordes, Kalenkoski, and Watson, 2000]. For each regulatory charge, columns identify the main payer or payee (if not a direct customer transfer), the affected customer groups, and markets. Most of the charges listed there are collected for wireless or wireline local or long-distance telephone service.

Access charges originated as a mechanism with the breakup of AT&T designed to compensate local telephone monopolies (ILECs) for the use of the local telephone infrastructure in originating, completing, switching, and holding lines open for long-distance calls. These flat fees charged to each local subscriber for connection to the long distance network were intended to prevent burdens on local phone companies that would otherwise have been covered by increasing business rates even more above residential ones.

Until recent FCC action [FCC 00-193, 2000], two access charges were assessed on *all* residential and *single and multi-line business* customers of ILECs. Businesses with local or long-distance voice (switched ISDN T-1's or point-to-point non-switched T-1's) or with local or long-distance special access lines (such as data T's or frame relay connections) did not pay such charges directly. Instead, prices for such derived lines were subject to special caps on pricing that could be used indirectly to collect access charges or by 5:1 or 9:1 ratios.

Table 5-12: Non-tax mechanisms: regulatory charges and fees

Item	Purpose	Payer (payee)	Customer	Market
SLC (Subscriber Line Charge) federal SLC.	Recover inter-state costs of local network use from "small" telephone customers.	(Multi-state ILECs)	C2,3,5,6	M1
PICC (Presubscribed Inter-exchange Carrier Charge)	Fee IXCs pay to LECs to recover cost of using local network for interstate telephone calls.	SP5 (SP1-3)	C2,5	M2
Indirect access cost recovery	Recover TS and NTS costs of using trunked access or special access and transport from "large" trunked businesses.	SP1-3 (SP4,5)	C1,4	M3-5
LNP (Local Number Portability)	Fee per ported line number to allow number to stay the same even if the local carrier changes.	(SP1-3)	C1-C6	M1
911 (911 charge)	Fund city-county 911 system.	(SP1-3)	C1-C6	M1
Telecommunication access system surcharge (TASS)	Funds telecommunications relay service for deaf.	(SP1-3)	C2-3,5-6	M1
Universal service charge	Support for interstate and intrastate high-cost, low-income, or schools, libraries, and rural telemedicine services.	SP1,2,5, 8,9 (varies)	C2-3,5	M2,4,8 (M1)
Payphone Surcharge	Reimburse payphone providers for calling card calls, toll-free calls, or pager response calls.	SP1-5,9 (pay cos.)	C1-C6	M1-2,7-8, calling card
NTW-800 charge	Charge for toll-free numbers	SP9 (IXC)	C1-6	M7-8
Plan or dial-around surcharges	Fixed fee to qualify for LD rate plan.	(SP5)	Varies	M2
Landline local access	Payment from wireless to LEC for intrastate use of network.	SP8-9 (SP1-3)	C2-3,6	M7
National access fee	Payment from wireless to LEC or IXC for interstate use of network.	SP8-9 (SP1-3,5)	C1-6	M7-8

Both the SLC (Subscriber Line Charge) and the PICC (Presubscribed Inter-exchange Carrier Charge, pronounced pixie) compensate local carriers for access to LD networks.

Specifically, both compensate ILECs for traffic-sensitive (TS) and non-traffic sensitive (NTS) costs of operating the local PSTN for interstate calls. The SLC is assessed on each local CCL (Common Carrier Line) or may be charged in ratio-derived units for blocks of derived lines (ALEs). The SLC also is called a federal subscriber line charge[16], since it is regulated and capped by the FCC. However, the SLC is not a tax since all monies go from customers to ILECs.

Until July 2000, primary residential line SLCs were capped at $3.50 per month, non-primary residential at $6.07, and multi-line business lines were capped at $9.38 per line per month[17]. A monthly fee of up to these amounts would be charged to all lineside customers of ILECs and embedded in prices used to resell ILEC lines to ALECs. Since the charge did not vary with traffic, it was meant to recover TS costs of using the ILEC local loop for interstate traffic.

The PICC charge is paid to LECs by IXCs. The PICC charge[18] originally replaced a TS charge (the CCLC). However, the PICC became a mechanism through which LECs could recover NTS costs of interstate use of the local access and local transport networks from IXCs that had not been recovered through the SLC. As such, the PICC was an indirect subsidy[19] because long-distance carriers were assessed the PICC charge by the local telcos on a per-line subscribed basis, regardless of how much that line used long-distance.

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[16] The SLC is also called the federal access charge, customer line charge, interstate access charge, FCC approved customer line charge, and by other names.

[17] The average PICC nationally was $7.17 per line per month.

[18] The PICC may also be called a national access fee, presubscribed line charge, carrier line charge, regulatory charge, or by other names.

[19] Both the PICC and SLC were also used by LECs as indirect subsidies to finance their contributions to the USF.

While all IXCs must pay PICC charges, the PICC charge has been passed on to customers in diverse ways. Some carriers do not collect it at all; others collect it based on call volume, while still others collect a fixed amount on a per-line basis. Additionally as shown in parentheses in Table 5-12, an ILEC may assess a PICC on a local customer who does not choose a long-distance carrier. The scheduled PICC cap for primary residential lines in July 2000 is \$1.56, while non-primary residential lines may have a PICC of up to \$3.58 per line per month. The multi-line business PICC cap had been scheduled to rise to \$5.90 per line per month in July 2000 (before the CALLS program was enacted).

Under the CALLS (Coalition for Affordable Local and Long-distance Service) plan for access charge reform (approved by the FCC in late May 2000), all residential and single line business PICCs have been removed. Additionally, the multi-line business PICC cap is lowered to \$4.31. However, residential SLC caps rise to \$4.35 for primary lines and \$7.00 for non-primary lines, while multi-line business SLC caps fall slightly to \$9.20 per line per month through 2004. The net effect of the CALLS plan is to shift the burden of access charges away from long-distance company customers (especially from low-volume customers) and towards local carrier customers.

Indirect access cost recovery is an even more complicated subject when trunkside or special access services are considered. On the surface, it might seem as though the ALE (Access Line Equivalent) basis would be the most efficient way to collect the access subsidy on switched and non-switched trunk lines. As was discussed in Chapter 4 (4.7 through 4.9), many kinds of trunks and multiple trunks use ILEC conduits, poles, and equipment to transmit local voice, long-distance telephony, data, and Internet communications. Furthermore, many businesses purchase services from carriers who utilize the ILEC's local loop or bypass that loop entirely with their own facilities. However, different kinds of access technologies have different impacts on local access and local transport networks.

For this reason, the FCC defined certain "baskets" of services provided by local carriers to IXCs or to customers. The service baskets are an attempt to clarify the sources and uses of direct access charges (such as the SLC and PICC), along with indirect access charges such as price-cap regulations. Based on whether a telephone, enhanced telecommunications, or data circuit fell into a common line (CMT) basket, TS switched interstate access basket, trunking basket, interexchange corridor basket, or special access basket, an appropriate mechanism(s) would be chosen to recover network access costs [FCC 00-193, p. B-26-B-27]

Consider, for example, three examples of business connections that use some part of the ILEC's local loop. Suppose that one business has twenty-three telephone lines through a switched ISDN or T-1 trunk, while another had twenty-three individual lines. For technical reasons, the access costs related to the trunkside services are a small fraction of those of the multiple-line (lineside) costs. Lineside costs are mainly in the CMT and TS basket, while trunkside costs have no TS component for the ILEC if the trunk's long-distance calls are not switched through the CO, but instead are switched at the IXC's POP. Most trunkside services are carried over ILEC facilities (whether sold by the ILEC directly or resold by an ALEC). However, the cost per trunked ALE might be below 5/23rd to 9/23rd the multi-line total (for technical reasons explained in Chapter 4).[20] Other kinds of lines such as a frame relay T-1 do not even carry telephone calls and have a different underlying cost structure for using ILEC facilities to access the ILEC or its competitor's frame relay network. Such data lines or other kinds of special point-to-point connections are examples of services from the special access basket. Competition for these enhanced telecommunication and private data networking customers is fearsome enough that the PICC and the SLC are often not charged by IXCs and ALECs.

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[20] In Common carrier Action CC 97-53, a ratio of nine to one was assigned for Centrex to PBX lines, reducing the PICC for Centrex lines by 8/9ths.

The issue of derived lines is so complicated it cannot be explained completely here. Importantly, though, customers of retail ALECs along with certain special access and trunking basket services are regulated indirectly through wholesale price-caps on ILECs. After adoption of the CALLS proposal, the Commission used a special X-factor (whose definition changed under CALLS) to seek indirect reimbursement for trunked and special access costs through changes in price-caps for certain ILECs [FCC 00-193, 2000, pp. 54-78]. Undoubtedly, this was in response to what the Commission had worried about in 1997:

> We are concerned that assessing PICCs on multi-line business lines may create an artificial and undue incentive for some multi-line customers to convert from switched access to special access to avoid the multi-line PICC charges. A migration of multi-line customers to special access could significantly reduce the amount of revenue that could be recovered through per-minute charges, and would result in higher PICCs for the non-primary residential and multi-line business lines remaining on the switched network. We tentatively conclude that we should therefore apply PICCs to purchasers of special access lines as well. [FCC, 97-158, paragraph 103]

However, after seeking comments on how to do this, the commission failed to discover a mechanism by which the special access basket could be so regulated at the time.

LNP is the next special charge in Table 5-12. LNP is a fee charged per multi-line to allow telephone numbers to stay the same even if a business or residence switches local telephone companies. One barrier to competition before the 1996 TCA was the fact that the numbering system was set up so that a business' telephone number would have to change if its local carrier changed. LNP charges vary based on the costs incurred by the ILEC. ILECs are allowed (but not required) to charge a LNP charge. For trunkside services, the nine (ALEs) to one common line ratio is not used for businesses with PBXs. Instead, the LNP is per ported line [FCC, "Local Number Portability Factsheet", January 1999]. LNP applies only to changes in LECs, not to changes in location. Therefore, a business that moves outside local exchange boundaries cannot be guaranteed the same telephone number whether it changes LECs or not. LNP charges can apply for a maximum of five years.

The next charge is the 911 charge. This charge is made on all single or multi-line business customers. For switched trunked lines, it may be charged using the nine to one ratio, though lines sold by certain ALECs or multiple trunks may be exempt[21]. The amount varies by county and depends on the cost for the ILEC and county to set up the 911 system. The per-line charge is normally less than $0.50 per month.

The telecommunications access system surcharge may be charged by ILECs to fund the telecommunications relay system for the deaf. It normally is under $0.20 per month per line for single or multiple lines. It may be collected by ILECs to reimburse their costs of running the relay system.

The universal service charge has already been discussed. The CALLS proposal adds a new USF mechanism (the IAS) to replace the implicit access charge subsidy from universal service in *interstate* rates. Hence, in addition to providing intrastate high-cost support and schools, libraries, and rural telemedicine support, a new mechanism is created to ensure interstate access universal service, while funding for low-cost support is absorbed (rather than charged to customers) by IXCs. The new mechanism will collect $650 million per year from LEC customers rather than the current method where long-distance customers indirectly support universal service through access charges [FCC, Sixth Report and Order in CC Docket Nos. 96-262 and 94-1, May 31, 2000]

Several minor mechanisms are shown in the remainder of Table 5-12. The first of these is the payphone surcharge. This charge was established to compensate payphone service providers for completed interstate and intrastate calls that use their payphones. Most calls from payphones are under contractual arrangements between pay providers, IXCs, and LECs. However, calls to toll-free numbers and calls that use payphones to access long-distance carriers (dial-around, calling card, or toll-free IXC lines) receive a 28.4 cents per-call completion charge from the IXC handling the call. In some cases, these charges appear on a business telephone bill. Pager users are also charged a monthly charge for 800 number calls (or other toll free numbers) and for use of 800 numbers through an NTW-800 charge.

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[21] Thus, 911 does not work on some business lines.

Calling plan or dial-around surcharges sometimes appear on bills with the word surcharge to suggest that government regulations are responsible for the fee. That is not the case. Calling plan charges are assessed by IXCs for certain plans whether or not any minutes are used while dial-around surcharges occur when an IXC's PIC code (10-10 plus a unique carrier number) is used to dial-around the pre-subscribed IXC carrier.

Finally, wireless telephone service has a landline local access fee (essentially an SLC) and a national access fee (similar to a PICC). These charges are payments from the wireless provider to a LEC or IXC to compensate those carriers for calls that originate or are terminated on wireless telephones but also use other carriers' networks.

The taxes on hypercommunications (shown in Table 5-13) are more easily figured than the special charges on hypercommunications in Table 5-12 because they are based on the total bill for specific services, rather than on any kind of indirect method. Both taxes and charges are summarized with their effect on lineside and trunkside telephone service in Table 5-14. Before summarizing the financial impact of the taxes and charges on agribusiness, specific taxes and charges paid to government (listed in Table 5-13) are described.

The first tax is the federal excise tax on communications services. This tax originated as a temporary luxury tax on telephone service in 1898 to pay for the Spanish-American war. The rate rose as high as 25% on long-distance calls in 1944, falling to 1% in 1982. In 1983, the federal excise tax was raised to 3% for toll calls and 2.7% on local service. Federal excise tax does not apply to private communication service including accessory services provided with an office PBX. Therefore, special rules apply concerning which enhanced telecommunications services are taxable [IRS, Publication 510, 2000]. The tax does not apply to Internet access, private data networking, or to WATS charges.

Table 5-13: Taxes and charges paid to government on hypercommunications in Florida.

Tax	Jurisdiction	Carriers collecting	Customers	Markets
Federal Excise Tax	Federal government	SP1-5,SP-8	All	M1,2, M3-4 (part)
State sales and use tax	State of Florida	All but SP6,7	All except C3,6 in M1	All but M6
Florida gross receipts tax	State of Florida	SP1-5, 7-11	All	M1-4, M5 (local), M7-8
Local option tax	City or county tax on utilities	Varies	Varies	Varies: M1,3,M5 (local),M7
Franchise charge	City or county for reimbursement for right-of-ways	SP8-11	All	M1-8
City/Local tax	City or county local sales tax	Varies	Varies	Varies

Florida has two state taxes that are assessed on particular hypercommunication markets. The first tax is the sales and use tax. During 1999, of $17.4 billion in gross sales by communications companies and $11.2 billion in net sales, over $736 million in sales and use tax was collected. The tax rate is 7% for toll calls, cellular, beeper, SMR, and two-way cable TV services. A 6% sales and use tax applies on installations, sale and rental of communications devices, or leases of communications equipment such as telephone systems [State of Florida, Department of Revenue, 2000]. In October 2001 a new communications services tax (s. 202.12, F.S.) will take effect designed to tax the actual cost of operating a substitute communications system and on satellite service as well. Under a 1997 law (s. 212.05(1) (e) 1. a., F.S.), sales tax cannot be imposed on Internet access, e-mail, or other on-line services. Nationally, goods and services purchased online are exempt from sales tax until October 2001. In May 2000, federal legislation passed the U.S. House extending a moratorium on Internet taxes until 2006. A similar Senate bill has not yet passed.

The second state tax is the Florida gross receipts tax. The gross receipts tax raised $304 million from telecommunications in Florida in fiscal 1998-1999. The gross receipts tax does not apply to private data networking, WATS, or Internet access. The tax rate is just above 2.5%.

Under current law, Florida counties and municipalities may tax local telephone service (net of access charges and other fees) up to 10% *or* broad-based intrastate telecommunication may be taxed up to 7%. The collection of local option taxes (also called municipal public service taxes) is based on the service address. The collection of such municipal taxes and the definitions of service providers and markets vary considerably. In some locations, tax authorities argue that the way municipal tax law is written it favors ILECs over ALECs for private line services (enhanced telecommunications). Sharon Fox, Tampa's Tax Revenue Coordinator, stated in 1996 that "barriers to entry" such as taxing an ALEC private line at 7% and an ILEC's at 0% seem to be "forbidden by the Telecommunications Act of 1996". However, she added, "municipalities must follow all provisions of the (state tax) law . . . " [Fox, 1996, p. 4].

The result has been a system under which taxes on hypercommunications are haphazardly collected in some parts of the state. Problems with address locations, service provider types, and markets are too complex for some local agencies to deal with. Generally, most municipal 10% taxes exclude Internet or any other service where communication does not originate *and* terminate within Florida. Under the new communications service tax scheduled to take effect in 2001, no municipality may collect a higher tax rate than was collectable on July 1, 2000.

Franchise fees are collected by local jurisdictions for right-of-ways for cableco and wireless providers. Additional local city or county property or special assessment taxes and surcharges may be collected in some instances in addition to the taxes mentioned.

Some argue that many benefits of deregulation have been canceled by increases in taxes and fees. Long-distance savings have been "virtually eliminated" by increases in the FCC equal access charge, PIXIE charge, and a 6% tax on long-distance from the ten-year old state tax on telecommunications (local and LD). Often such local taxes are not itemized as to city or county and are often billed incorrectly even when numbers or jurisdictions change [Taylor, 1999]

Table 5-14 attempts to summarize the impact of taxes and regulatory fees on Florida agribusinesses depending on whether multi-line POTS or trunked enhanced telephony have been purchased. The impact of taxation and fees on the agribusiness' hypercommunications bill is multi-faceted. Taken together, the monthly costs for businesses of taxes and charges can approach 40% of the local telephone bill and exceed 25% of the long-distance bill. Florida has one of the highest average burden of taxes and fees of any state, estimated at 28.5% of the average residential bill (higher for multi-line low-volume LD businesses). The result is that Florida is ranked second nationally in taxes on telecommunications [Cordes, Kalenkoski, and Watson, 2000]. The tax and fee burden is less for enhanced telecommunications services, still less for private data networking, and almost non-existent for Internet access.

First, ILEC customers are likely to pay higher charges for local telephone service than ALEC customers. Local single-line and multi line telephone customers tend to pay more than customers who choose switched ISDN T's or T-1 point-to-point lines even if the ALEs are equal (each has the same number of lines).

As Table 5-14 shows, the 1:9 (a 1:5 ratio in some cases) ratio will keep trunked costs lower for businesses equipped with a suitable PBX than for businesses with multi-line or key systems. Second, businesses that bypass the ILEC switch and use special trunked access to switch long-distance through an IXC POP benefit as well. For example, a business that purchases a long-distance T or fractional T avoids PICC charges entirely (except through a small allowance on the rate that the ILEC charges the IXC for calls over the local loop). However, long-distance rates are competitive enough that the volume of calls ensured through this arrangement guarantees the business a still lower rate. Furthermore, since ALECs do not have the same interstate obligations, they sell such private trunks for a lower price, allowing businesses to save taxes on the difference in total charges in the process.

Table 5-14: Monthly costs to businesses of taxes and other mechanisms of involvement.

Item	Lineside	Trunkside
SLC	Single line capped at $4.35, Multi-line capped at $9.20.	Collected indirectly or via 9:1 (or 1:5) ratio.
PICC	Single line up to $3.50, multi-line up to $4.31	Collected indirectly or via 9:1 (or 1:5) ratio
Indirect access cost recovery	NA	X-factor price-cap rules, cost embedded in circuit price.
LNP	Fixed per ported number, varies by carrier cost. Usually less than $0.50 per ported line	
911	Fixed <$1.00 line	Varies
TASS	<$0.20	NA
Universal Service	Pre-CALLS average per line was $2.00; LD charge up to 6%. New charges per line will rise as LD contributions fall.	Typically not charged directly except by ILECs.
Payphone Surcharge	$0.28-0.30 per call	$0.28-0.30 per call
NTW-800 charge	Fixed $5.00	Varies
Landline local access	Similar, but lower than SLC	NA
National access fee	Possibly phased out by CALLS	NA
Taxes and government charges		
Federal Excise Tax	2.7%-3%	2.7%-3%
State Sales and use tax	6-7%	6-&%
Florida gross receipts tax	Up to 2.564%	Up to 2.564%
Local option taxes (municipal utility taxes)	7-10%	To 7%
Franchise charge	Fixed	Fixed
Other city or local taxes	Vary by jurisdiction	Vary by jurisdiction

A third effect of taxes and regulatory charges is that enhanced telecommunications market benefits and the POTS market (in particular the ILEC POTS market) suffers. Another result of asymmetric taxation is that private data networking and Internet access markets benefit even more than enhanced telecommunications. Frame relay connections and Internet T's still use ILEC infrastructure. However, since these "special access basket" lines cost ILECs less than switched or dedicated voice lines and since total charges are lower taxes as well. Many fixed fees do not apply at all for special access circuits.

Finally, another result of high taxes is that Florida (with the second highest tax rate on communications in the country, 28.46%) disadvantages agribusinesses (and other businesses) located in the state. State and local taxes in Florida represent an average of 24.47% of the average residential single-line telephone bill. Idaho (the state with the lowest burden) has an average state tax of 3.94%, which amounts to less than 8% of an average residential telephone bill when federal charges are added in. Georgia's state burden is 18.98%, Alabama's is 19.89%, and California's stands at 15.99%. Only Texas, with an average state and federal tax rate of 28.56%, is higher than Florida [Cordes, Kalenkoski, and Watson, 2000]

Short of leaving Florida, agribusinesses can reduce tax burdens by switching fax and data traffic off POTS lines or enhanced trunks. By doing so, businesses further reduce overall communications costs, avoid PSTN-based taxes and regulatory charges, and lower their total tax bills. In addition, firms that use IP PBX solutions based on VOIP and VOFR (see Tables 4-39 and 4-40) cut bills, taxes, and charges even further. The greatest savings occur for agribusiness communications that originate and terminate within a VPN (4.9.7) since private networks are subject to fewer taxes. However, many such alternatives have still have significant QOS issues, making them questionable for some business-class communications. Even if the technologies improve, most PSTN calls and fax traffic still terminate on PSTN lines (at the recipient's location) so that some PSTN costs still must be borne by the calling party.

A more specific breakdown of the costs and savings involved will be found in Chapter 7. Before providing a more general model of the policy implications through several economic analyses in 5.6, two last mechanisms are used by governments in hypercommunications.

5.5.3 Carrier of Last Resort

Another mechanism of government involvement is the COLR (Carrier Of Last Resort) provision. Currently, COLR obligations exist for ILECs in Florida to provide basic telephone service. As competition occurs in the LEC market, universal service and other subsidies (such as the charges shown in Table 5-12) tend to be charged only by ILECs. However, customers (especially those who are most heavily responsible for financing cross-subsidies) will tend to leave the ILEC if prices are lower with ALECs (who do not have COLR responsibilities).

An important question concerns whether COLR obligations should be set at high or low levels as competition occurs in local service. This is particularly relevant when considering competition in hypercommunications between ILECs and other COLR utilities (such as cablecos and electricos who provide telephone service using cost structures that arise from COLR schemes for electricity or cable TV). If an ILEC COLR carrier is obligated to reach all customers in a service area, then COLR providers of electricity or cable TV might have to be able to serve all hypercommunications demand for their COLR customers.

According to Weisman, the level of the COLR obligation sets the reliability of the COLR carrier and its competitors [Weisman, 1994]. According to the Weisman model, the optimal COLR obligation is less than 100%, but greater than 0% because if the COLR obligation is zero, competitors will undersupply reliability. However, if the COLR is set to 100%, competitors will oversupply reliability since they do not take into account the prices needed to cover the COLR carrier's cost of excess capacity [Weisman, 1994, p.97]. Convergence would tend to exacerbate the inefficiencies of COLR provisions.

There are additional risks for COLR carriers due to convergence. For example, ILECs are already required to provide universal service. However, they could also be required to provide high-speed Internet access and other hypercommunication offerings (including traditional and enhanced telecommunications services) if states or federal authorities expand the obligation to universal access. Florida law and FPSC policy requires COLRs to extend service to distant but not extremely remote places. It is not easy to differentiate between distant and extremely remote.

One case that shows the difficulty of the distant versus remote COLR distinction concerns Dog Island, Florida. In 1985, homeowners on the island off the Florida panhandle (near Carrabelle in Franklin County) requested telephone service from their ILEC, the St. Joseph Telephone, and Telegraph Co. It was not until 1993, that fifty island residents made known their (still unacted upon) requests to the FPSC. Due to a variety of concerns regarding the environmentally sensitive storm-prone island, underwater cable facilities from Carrabelle (four to six miles away) could not be constructed. Such a submarine cable would cost $750,000 dollars to extend service to a maximum of 125 households at a cost of six thousand dollars each. However, the ILEC could only charge the normal per residential line charge of under $20 per month to recover costs. St. Joseph's was ordered to extend service (in keeping with its COLR obligation) using a radio transport link to shore from a wireline CO on the island at a cost of several hundred thousand dollars [Dog Island VS. St. Joseph Telephone Co., Docket #950814-TL, Order No. PSC-97-1196-FOF-TL, FPSC, October 2, 1997]

The FPSC has held that ILECs are required to provide non-discriminatory service throughout their territories. Hence, ILEC facilities must be extended to offer Universal service to "consumers in all regions of the nation, including . . . those in rural, insular, and high-cost areas". Furthermore, "those areas should have access to telecommunications and information services . . . that are reasonably compared to services provided in urban areas. . . . " [47 U.S.C. § 254(b)(3), 1996 TCA]. Yet the FPSC does not appear to think that the current FCC definition of universal access (200 kbps) will become workable in Florida anytime soon.

Recently, the commission staff found that "over 60 percent of Florida wire centers were incapable of providing xDSL service. Until the LECs are further along with deployment of this capability, no redefinition of local exchange service" or requirement for high-speed service "should be considered" [FPSC, 1999, p. 1]. The report points out that the "*average data rate* *available to consumers will rise to 56 kbps*" in the next three to years. According to FPSC staff, all that is needed is monitoring of the situation "to determine whether a redefinition of basic service might be appropriate in the future." [FPSC, 1999, p. 1]

5.5.4 Spectrum Allocation

Another important mechanism used to affect hypercommunications is spectral allocation. Because there can only be one user of a particular frequency at one time, spectral allocation has been left to the FCC (Federal Communications Commission) in the US. According to Francois in 1978, there are four essential concepts that provide the rationale for spectral allocation: public ownership, scarcity, media differences, and fiduciary [Francois, 1978, pp. 436-437]. By this multi-pronged rationale, the federal government was assumed to have the right to allocate spectra ranging from sub-sonic physics particle generators through infrared light.

Many of the dimensions of spectral allocation can be seen in Chapter 4 in Figures 4-30, 4-32, and 4-33 where the location of various wireless services in particular bands can be noted. Spectral allocation is being used in several ways to ensure competition and increase high-speed services. First, in recent years the FCC has transferred from government and scientific use huge parts of the frequency band to accommodate new services. The new upperband frequencies (generally above 20 GHz) are especially attractive because they offer greater bandwidths so that high-speed services may be accommodated.

A second way spectral allocation serves as a mechanism comes from specially controlled auctions held by the FCC when new frequencies are released. The auctions are set up to maximize the economic efficiency of the results[22]. A third way spectral allocation is used as a mechanism is the relaxation of the spectrum cap in rural areas. According to the FCC, the

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[22] Cramton provides a comprehensive overview of the efficacy and economic efficiency of early FCC spectrum auctions [Cramton, 1997]

"spectrum cap governs the amount of CMRS spectrum that can be licensed to a single entity within a particular geographic area." [FCC, Wireless Bureau, September 15, 1999, p.1] By relaxing the spectrum cap in rural areas, the FCC feels that certain firms will be encouraged to enter those areas to provide 3G high-speed wireless services. Additional discussion concerning the boundaries used by the FCC to determine a rural area within which different kinds of wireless carriers may be licensed is found in Chapter 6.

5.6 Convergence and the Economics of Regulation

This section starts by presenting a general conceptual model (5.6.1) that is then used to examine three topics in convergence and the economics of regulation of hypercommunications. The issues of rate rebalancing and rate averaging to provide universal service in a dynamic converging marketplace are covered in 5.6.2. A general summary of the problems of using incentive and traditional utility regulation to achieve policy goals in hypercommunications is given in 5.6.3. Finally, a general analysis of the possible economic effects on agribusinesses of *status quo* policies involving asymmetric taxation and regulatory charges is the subject of 5.6.4.

5.6.1 Conceptual Model

Until now, the discussion of rationales for government involvement in hypercommunications and the mechanisms used to make policy have focused on complexities in the current marketplace save one important exception. The converged hypercommunication market has been ignored in favor of separate markets for POTS, enhanced telecommunications, private data networking, and Internet. Each market has been examined technically (in Chapter 4) and in regulatory terms (in Chapter 5) as though it could be separated from the others. As technologies progress, such separation becomes less possible. However, regulators continue to treat one group of services differently from others.

The problems with this asymmetric approach to regulation are illustrated through Table 5-15. There, an example given by Fox in 1996, is extended to show the ways that a person employed at a firm located in Tampa might communicate with an associate in the Jacksonville branch office [Fox, 1996, p. 9]. The example is important to agribusiness managers because it encapsulates the technical, economic, and regulatory factors of hypercommunication networks that have been established from Chapter 2 until this point. Table 5-15 (and the conceptual model it gives birth to) highlight two important issues for agribusiness managers. First, hypercommunications policy has an impact beyond rural infrastructure development. Regardless of the rural infrastructure, taxes and regulatory charges appear on bills each month, even up to forty percent of the total cost in some cases. Competitiveness, QOS, and pricing are all affected by utility regulation policy as well.

Second, because of these regulatory impacts on agribusinesses' bills many counterintuitive results occur. Rural businesses pay higher rates than urban residents even as urban businesses and residences pay higher rates than they otherwise would to subsidize rural access. Competitors of local telephone monopolies become more attractive since they may not collect certain regulatory charges. Furthermore, as convergence allows businesses to communicate by voice, video, Internet, fax, and e-mail without using the telephone network, additional advantages can flow to innovative firms. If an agribusiness can buy more communication for less than half the price and reduce communication taxes by an even greater percentage, it bears looking into. However, there are QOS and financial risks involved.

Table 5-15 displays four classes of communications ranging from real-time voice conversations (CLASS 1) to fully interactive collaborative two-way simultaneous voice, text, data, graphics, and video hypercommunication (CLASS 4). Within each class, several examples of service offerings are listed that are capable of delivering that overall class of service.

Table 5-15: Classes of hypercommunication messages and within-class delivery technologies.

Ex.	Description	Tampa technology	Jacksonville technology
CLASS 1: Real-time voice conversation			
1A	Inter-LATA LD single-line telephone call	POTS	POTS
1B	Inter-LATA LD landline telephone call via derived channel	Enhanced telecommunications	POTS or enhanced telecommunications
1C	Inter-LATA LD wireless telephone call	Wireless phone	POTS
1D	VOFR	Private data network	Private data network
1E	VOIP via VPN	Internet & VPN	Internet & VPN
1F	VOIP	Internet	POTS, Private data network, or Internet
CLASS 2: Text message (one-way)			
2A	Inter-LATA long-distance fax	POTS	POTS
2B	Fax server	Enhanced telecommunications	Enhanced or POTS
2C	Fax server via frame relay	Private data network	Private data network
2D	Wireless pager or wireless phone (voice-to-text) to remote fax	Wireless telephone or pager	Enhanced or POTS
2D	Fax via Internet VPN	Internet & VPN	Internet & VPN
2F	E-mail via Internet	Internet	Internet
CLASS 3: Data or graphics message, one-way			
3A	Point-to-point (modem to modem) data transmission	POTS	POTS
3B	Modem-modem via PBX or smart T	Enhanced telecommunications	POTS or enhanced
3C	WAN file transfer	Private data network or enhanced	Private data network or enhanced
3D	E-mail w) attachment, FTP, Intranet, web-based, etc	Internet with or without VPN	Internet with or without VPN
CLASS 4: Interactive or collaborative two-way messages (simultaneous voice, text, data, graphics, and video)			
4A	Modem-modem or channel-bonded modem-modem hookup	POTS	POTS
4B	Special services (CAC circuits)	Enhanced telecommunications	Enhanced telecommunications
4C	WAN with collaborative software	Private data network	Private data network
4D	Internet	Internet with or without VPN	Internet with or without VPN

In general, the older the hypercommunications technology (within each class or among classes), the greater the amount of regulation and taxation. For example, single-line local or long-distance telephone calls (Example 1A) have far more regulation and taxation than simultaneous voice, text, data, graphics, video, and collaborative networking using Internet access.

There are three ways to analyze Table 5-15: within classes, among classes, or on an offering-by-offering basis (as hypercommunication bundles). First, consider comparisons among the service offerings (examples) within classes. Here the comparison is among different technologies capable of delivering the same message type. Suppose the price of one service offering equaled that of an extremely close substitute offering (capable of delivering the same message) within the same class. If the tax produced significant differences in costs, the higher-taxed provider would be expected to lose customers to less-taxed competitors. The same would be true if due to regulatory reasons, one offering arbitrarily charged higher prices.

Of course, an important assumption is the word "close substitute". As Chapter 4 examined in detail, the QOS characteristics of a particular message type can vary dramatically by technology and service provider. Since the equivalent service offerings are provided by different technologies, all costs (economic and accounting) must be considered. This point is important because most service offerings within classes or among them are substitutes, but rarely are they perfect substitutes.

When the second level of analysis, comparison among classes is considered, units of analysis (both prices and quantity) can vary among classes, making analysis difficult. Instead of calls or call-minute-mile, other units, such as kbps transmitted (data rate) or bandwidth (capacity) may be used. Here the comparison is among different message types. However, if the alternatives to one class were close communication substitutes *and* offered additional services for no additional charge, highly regulated and taxed classes would become less popular because customers could *pay less* and receive *greater value.*

The variable cost of communication tends to fall for entries as the table is descended, both within each class and among each class. For example, within example 1, a ten minute overseas telephone call (via POTS single-line) might have a low monthly recurring cost, but a high variable cost when compared to any alternative voice communication method below it. However, as successively lower voice examples in the list are considered, the greater the total monthly recurring costs would be relative to variable or per message costs.

The third level of analysis would compare hypercommunication bundles within a class *and* among classes (each entry in the table with all other entries). The advantage of this characteristics-based method is that within-class and among-class differences could be analyzed, along with any interaction effects. A simple conceptual model (interaction effects not shown) of the economic costs of choosing a hypercommunications bundle from a given carrier is given by equation (5-1):

$$\mathrm{COST} = f\,(\mathrm{C\&I, RACC, RTR, VACC, VTR, OTHCOSTS; TAX, QOS}). \quad (5\text{-}1)$$

Where:

COST represents the economic cost to an agribusiness of service offering i within class j for carrier k, during the recurring period.

C&I is the LR fixed cost of CPE and installation over ijk

RACC is the SR recurring cost for network access over ijk

RTR is the SR recurring cost for network transport over ijk

VACC is the VSR variable cost for access over ijk

VTR is the VSR variable cost for transport over ijk

OTHPRICES are costs of available substitutes and complements

TAX is a set of taxes and charges over ijk

QOS is a vector of Quality Of Service characteristics over ijk.

Given the differences in VSR, SR, and LR and time compressed periodicity as technology progresses (2.5.2.5), the agribusiness hypercommunication outlays have many cost levels that would influence demand for a particular offering, class, or carrier. Each variable would affect costs differently. Furthermore, even if the variable units (those associated with VTR and

VACC) could be derived into kbps the price per unit might not be easily convertible. Additionally, the units the associated with recurring charges (RTR or RACC) would still differ among alternatives. For this reason, rather than trying to separate prices and quantities, equation (5-1) may be thought of as a relationship among costs.

C&I refers to the capital cost of purchasing suitable CPE, software, employee training, and installation costs for the local infrastructure the agribusiness uses at its location(s) to communicate. It is an example of a long-run cost. Long run in this sense refers to the fact that equipment upgrades occur infrequently. Such long-run costs are often forgotten except when agribusinesses switch from one service to another.

Recurring access (RACC) and recurring transport (RTR) costs typically use monthly (recurring period) charges that are also influenced by length of run of contracts. Recurring charges are examples of SR non-traffic sensitive costs. However, by encouraging the use of long-term contracts, many service providers effectively make recurring charges more "long run" than CPE decisions. For example with dial-up Internet service, RACC is the monthly cost of the telephone line paid by the customer to an ILEC or ALEC, while RTR is the monthly cost of Internet service paid to an ISP or OSP.

Variable access (VACC) and variable transport (VTR) costs are per message, per call, per minute, or other traffic sensitive charges that may vary according to time of day, distance, or network congestion loads. These measures may be VSR for two reasons since they can vary day-to-day or hour to hour[23]. With a single-line POTS line used for long-distance (LD) telephone calls, VTR would be the per-minute toll rate for use of the IXC LD network. VACC is the charge per-call or per-minute the IXC pays the originating and terminating LEC. In the case of telephony, VACC is usually embedded in VTR. The PICC was originally intended to replace the CCLR to compensate ILECs for *local* VACC incurred in LD calling.

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[23] Enhanced telecommunications CPE (4.7.1) and AIN call center services (4.7.2) can be combined so equipment automatically "shops" for the cheapest LD rate between two points when a call is placed without the user realizing it. Such tool databases are coming into wider use for data networking as well.

However, in other cases VACC could be broken apart from VTR. One example is ISDN-BRI Internet service. The LEC that provides the ISDN line may charge a per-minute or per kbps rate (VACC) for traffic over the ISDN access line from the agribusiness to the ISP's POP in addition to RACC. Some ISPs charge per kbps charges (in addition to a monthly recurring fee, RTR). Even though such (VTR) charges are called Internet access charges, they are essentially transport charges because they cover costs incurred by the ISP for the ISP POP to Internet NAP (backbone) link.

Taxes (or regulatory charges) may be placed on any or all elements. Federal excise, Florida gross receipts, and most municipal taxes are ad valorem taxes assessed as a percentage of the total bill. These are rates on the total (RACC, RTR, VACC, and VTR) for service examples or classes that qualify for the tax. Other taxes or charges are based on the number of connections. For example, the PICC and SLC are assessed on a per-line basis. Special charges such as these may be collected only by certain carriers (non-rural-certified ILECs) on regulated service classes or specific examples. Later in 5.6.4, tax aspects of the conceptual model in (5-1) will be analyzed. The OTHCOSTS variable, which represents the set of available substitutes and complements, is important because the choice set is governed by what is available in a given location.

QOS (Quality of Service) variables include factors such as reliability, delay, capacity, and speed that affect the quality of hypercommunications. These are normally economic costs, but not accounting costs except when pricing depends on SLAs (Service Level Agreements). Table 4-3 in 4.2.4 provided a list of fifteen QOS dimensions.

The conceptual model helps agribusinesses realize that hypercommunications is governed by numerous network interrelationships. C&I is a proxy for the local network investment made by the agribusiness, RACC and VACC capture costs at the access level, and RTR and VTR represent the transport level. Each level is subject to different regulatory restrictions. The general

QOS reference model shown in Figure 4-14 (in 4.2.3) may be consulted for review. A more specific version of the conceptual model will be used in Chapter 7 to aid agribusinesses in understanding the specific economic costs associated with service examples or classes and each carrier. There, the conceptual model can be extended to each level as well over class, form, and provider.

This remainder of 5.6 will use the general conceptual model just introduced to consider three regulatory issues. For each issue, the traditional regulatory approach is presented along with an analysis of how convergence changes the economics of that issue. It is likely that the structure of hypercommunication markets throughout Florida will be affected for some time by regulatory lag or the tendency for regulation to lag well behind technological change.

5.6.2 Rate Rebalancing and Universal Access

The first issue concerns the idea of rate rebalancing and universal access. Rate rebalancing is concerned with aligning prices and production costs more closely. When rate averaging has been followed as a policy (such as geographical averaging of rates for universal service), rate rebalancing seeks to make the average rate more economically efficient, often as a preface to the complete deregulation of rates. According to Sappington and Weisman, "if competition is encouraged in the telecommunications industry . . . rate rebalancing can limit cream skimming, and can help ensure that services are purchased from the least cost supplier." [Sappington and Weisman, 1996, p. 119] Traditional approaches have focused on universal telephone service, seeking to balance access and transport prices with access and transport costs, and on balancing urban and rural rates with appropriate costs.

Figure 5-13 illustrates one aspect of rate rebalancing, the differences between the geographic averaged rate and marginal cost of providing telephone service as population densities fall. On the left panel, the example shows the monthly rate for telephone service on the y-axis, along with the amount per line that would be need to bring rates into equity at the averaged rate.

Subsidizers pay a subsidy equal to the difference between the cost-based price and the average rate, while subsidized customers receive a similar amount.

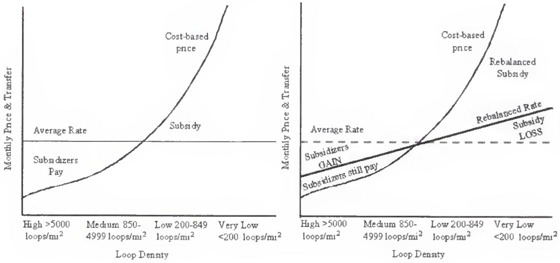

Figure 5-13: Rate rebalancing of local telephone service in price-density space.

When rates are rebalanced (as shown in the right-hand panel), subsidizers gain an area equal to that lost by subsidized customers. While a subsidy still occurs, it is smaller (more balanced) than under the initial average rate. Figure 5-12 also depicted rate averaging (in price-quantity space) during the discussion of universal service mechanisms in 5.5.1. Of course, one problem (and the reason rates may need rebalancing) is how the average rate line is arrived at. However, when convergence is combined with rate rebalancing it becomes especially difficult to see who should be subsidized and who should be the subsidizer. Beyond the obvious issue of locating the rebalanced rate line, there are many other issues regarding rate rebalancing (even before convergence) that cannot be covered here.

However, several pertinent points need at least to be listed before the complications caused by convergence to rate rebalancing are considered. First, as was discussed in 5.4.1, the unit of analysis matters. The rates to rebalance can be calculated on several bases. For example, local telephone service can use CCLs or ALEs while long-distance can use minutes, call-minute-miles, or total bill. New technologies cause problems when units of analysis are improperly combined. Unit differences between technologies can be equalized using derivations such as ALE-CCL ratios. However, a single common carrier line and a set of virtual ALEs carried on a single trunk have non-linear differences in costs and prices that a ratio alone cannot control for. Adding a further level of complexity, derived enhanced telecommunication channels can be used for local and long-distance telephony as well as for data networking and Internet access. In the case of "customer reconfiguration controlled" smart T's (discussed in 4.7.4), deriving channels is made harder since the circuit automatically makes virtual adjustments among voice, data, and Internet channels based on customer traffic patterns. Not only are derived lines capable of different uses, but they are capable of dynamically configuring themselves to those different uses, making comparison with a POTS line impossible.

Convergence changes analysis of rate rebalancing in two chief ways. First, under convergence, universal access to hypercommunication networks rather than universal telephone service becomes the objective of rate rebalancing. Second, the unit of analysis, therefore, shifts from local telephone access lines to some kind of kbps per month (VACC) or bandwidth/capacity measure (RACC). Figure 5-14 illustrates this through a hypothetical situation with four carriers who provide a hypercommunications service (rather than telephone service) with the price line now showing monthly price per kbps. The location of the average rate line (not shown, but left to the imagination) would affect each carrier differently. An important question to be kept in mind is whether recurring or variable access charges (or both) need rebalancing.

The four carriers are a cableco, an ALEC, an ILEC, and a wireless provider. The cableco and the ILEC are COLRs so that their costs represent at the very least the fact that their infrastructure (if not their operating costs) benefit from a combination of size and possible cross-subsidies. The ALEC exhibits classic skimming behavior. As a smaller size firm without the burden of a COLR obligation, the ALEC targets the ILEC's most profitable customers. Since it can resell ILEC access facilities (such as the local loop) at regulated interconnection rates, the

ALEC can skim away the cream of the most profitable customers from the ILEC. The wireless firm is smaller still. Its costs of serving a dense area are dependent on technical issues such as those mentioned in Chapter 4.[24] The wireless firm in Figure 5-14 is able to serve the sparsest area at the lowest cost to customers.

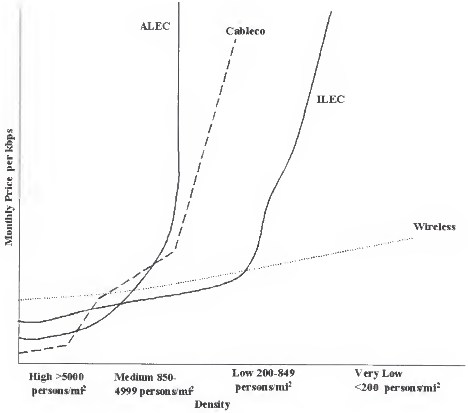

Figure 5-14: Four carriers have different least-cost service areas where population density is concerned.

Each carrier has a density level (shown on the x-axis as persons per square mile). The cableco can serve customers more cheaply in the densest area (over 5000 persons per square mile). The ALEC is able to serve a density just above the medium density more efficiently since the cableco costs begin to rise at that point. Next, the ILEC is the low cost provider until the low-density zone is reached where the wireless carrier remains the most efficient provider as densities fall.

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[24] Indeed, it is more costly for some wireless technologies to serve densely populated areas due to buildings and other sources of interference. However, the frequency range of upperband technologies can prevent other wireless carriers from effectively serving sparsely populated areas. Section 4.4 covers details of wireless transmission technologies in enough detail that almost any shape of density-price curve could be drawn in Figure 5-14 for a hypothetical wireless carrier.

It could certainly be argued that rebalancing of averaged rates (under the pre-convergence regulatory structure) is no longer necessary since market convergence has removed the worst of the inequity between rural and urban. However, the effect of removing an averaged rate overnight could influence competitors differently. COLRs in particular might be disadvantaged. In absolute terms, the urban-rural differences appear smaller than the hypothetical case shown in Figure 5-13. Remember though that the units have changed. Furthermore, if the public infrastructure investment rationale (5.4.2) applies, the fact that the densest location is some six to seven times more cheaply served than the sparsest may support the case for continued rate averaging. However, if the cableco and the ILEC are both subsidized and are still enjoying the fruits of past supernormal profits due to regulatory inefficiencies, an anti-competitive bias may be present.

Yet even in the case of a single firm, rebalancing rates is not an easy exercise. In addition to trying to prevent the regulated firm from losing money or making supernormal profits, the effect of the rebalance on each density group must be considered. With four carriers, four density groups, and four costs, the effect of rebalancing one average rate (much less establishing that rate to begin with) would be an extremely difficult task that could easily result in new inefficiencies.

Rate rebalancing has some interesting dynamics if the ALEC buys the wireless carrier and the cableco buys the ALEC in response as shown in Figure 5-15. Here, the ILEC/cableco is the low-cost provider in the highest density area and in the medium to low zone. The ALEC/wireless is low-cost at middle-high densities and at low to very low densities. Again, placement of the average rate line would be important, but there is no clear-cut economic level where it "should" be placed. Interestingly, had the hypothetical acquisition been different, one carrier could be placed in the position of always subsidizing the other carrier. The effect of such mergers on price even in rural areas can be positive. For instance, Levin and Meisel found that when rural telcos buy rural cablecos monthly prices fall by eight percent on average [Levin and Meisel, 1993]

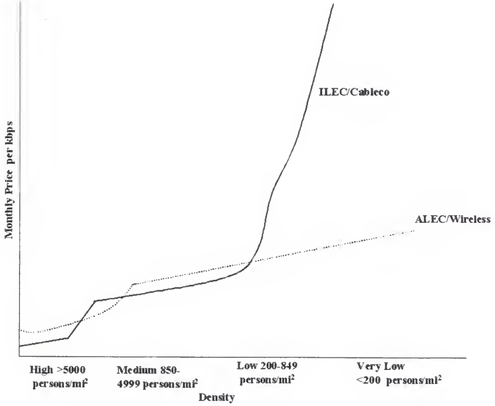

Figure 5-15: Example of how hypercommunication mergers could influence pricing by density.

Rate rebalancing is also concerned with the differences among residential, business, and SOHO (Small Office Home Office) customers. Business rates may be two to three times higher than residential rates, even though it may be less costly to serve most business subscribers. Through such a demand segmented (price discrimination) approach a subsidy of residential service by businesses occurs because more inelastic business demand will bear a higher price. However, SOHO users are able to circumvent the division between business and residential markets. It is becoming difficult to identify business users from residential users since SOHOs and telecommuters can easily order circuits at residential rates. In both cases, costs may be cut in half; telecommuters would be reimbursed by their delighted firms while garage start-up SOHOs would save on entry costs and receive tax deductions.

Rate rebalancing is also concerned with the economics of balancing costs and rates between local access and long distance telephone transport. According to Sappington and Weisman,

> rather than distort access prices to preserve artificially high intraLATA toll prices and artificially low basic local service rates in the presence of competition, it may be advisable to reduce regulated prices. When toll prices and basic local service rates better reflect marginal production costs, access prices can also be moved toward marginal production cost without encouraging excessive cream skimming. Undesirable bypass can also be limited by such a rebalancing. [Sappington and Weisman, 1996, p. 248]

A wider focus could be to expand rebalancing between access and transport among classes in Table 5-15 within the conceptual model, rather than the *status quo* approach of focusing on two examples (LD and local telephony) in a single class. Unless *status quo* universal service contributions are expanded to include data networking transport and Internet access and transport, rate averaging mechanisms cannot meet the "universal access" 200 kbps standard of high-speed network access defined by the FCC [FCC CCB, FCC 00-290, 2000]. If this is true, the luxury of rebalancing these rates may not be available to regulators.

Even if universal access in rural areas could be supported by universal service mechanisms, the policy will mean that urban telephone customers will pay for rural business and consumer access to non-PSTN hypercommunication networks. That would likely be a case where rates become more unbalanced than rebalanced. As convergence continues, rate averages may become more out of balance rather than rebalanced, unless new mechanisms are enacted. However, ISPs and data networking providers and their customers have fought extremely hard to see that no such result occurs. For these reasons, existing subsidies along with regulatory alterations may be necessary if universal access is to be achieved. As the next section shows, policy may not be able to implement universal access without deepening existing regulatory asymmetries and inefficiencies.

5.6.3 Convergence and the Application of Incentive and Traditional Utility Regulation to Hypercommunications

The next topic relates to rate rebalancing but is much broader. The literature on utility regulation is immense. All this sub-section can do is briefly cover four main issues involving agribusiness hypercommunications as shown in the conceptual model. More expansive treatments are found elsewhere on topics such as the fundamental postulates of telecommunications demand under regulation [Taylor, 1994] or the principles of utility regulation [Berg and Tschirhant, 1988].

Agribusinesses have two chief reasons to be interested. First, expansion of access to hypercommunication networks in rural areas is one way regulation influences Florida agribusinesses. On this first issue, concern focuses on the mere availability of classes of services. A second issue deals with the costs agribusinesses pay, service quality, and market competitiveness in general. On this second issue, concerns include pricing and the use of deregulation, regulation, and re-regulation to prevent market failures or negative network externalities. The objective of traditional and incentive utility regulation is to deal with concerns over pricing, access, and competitiveness as they influence rural areas and agribusiness constituencies, as well as urban businesses and consumers.

The first topic is to sketch out traditional regulatory theory and incentive regulation and apply them to a convergence scenario for agribusinesses. Traditional regulatory theory focuses on monopoly behavior under several regulatory regimes. Importantly, deregulation and technical change are erasing monopoly structures so that regulatory theory will need to apply in imperfectly competitive markets instead. According to Gong and Srinagesh, the economic model necessary to support the NII (National Information Infrastructure) would have "oligopolistic competition among a few large companies that invest in the underlying physical communications infrastructure" with "network and call externalities at the virtual network level". Additionally, there would be "large sunk costs and excess capacity in underlying transmission links" [Gong and Srinagesh, 1997, p. 66]

The first regime, strict rate-of-return regulation is depicted in Figure 5-16 [Adapted from Sappington and Weisman, 1996, p.109]. Rate-of-return regulation is still used by the FPSC for several rural-certified ILECs in the state. The FPSC defines the rate-of-return method as:

> . . . the Commission determines the amount of revenue a firm needs in order to provide services. This determination involves establishing the appropriate rate of return and allowable rate base and expenses for the firm. Once the company's revenue requirement has been established, rates are set to produce that level of revenue. This process constrains the company's ability to act, or react, quickly to competitive changes. In order for the company to change rates either up or down, it must come to the Commission for approval to do so. [FPSC, "Understanding the Local Telecommunications Competitive Environment", 1999, p.1]

The first step involves setting a TEL (Target Earnings Level) for each regulated firm. Rate of return regulation may be used to set indirectly any of the prices of the conceptual model (RACC, RTR, VACC, and VTR). Importantly, the effect on specific service offerings, among service classes, or on particular providers is uneven. Furthermore, unless every product of a particular provider is regulated, rate-of-return regulation requires that within-provider costs be "allocated" to particular services even for large, multi-product firms. Hence, it can be difficult to control prices through earnings for a multi-product carrier that has a mix of regulated and unregulated services.

Under strict rate-of-return regulation, the TEL is set by regulators with the idea that it represents a "fair" economic return. Information about what constitutes a fair return is necessarily derived from cost and accounting data from the regulated firm itself, presenting an important problem. The regulated firm has more information about these costs that the regulators. For this reason (and due to the tendency of the method to allow inefficiencies to become fixed) strict rate-of-return regulation has become much less used.

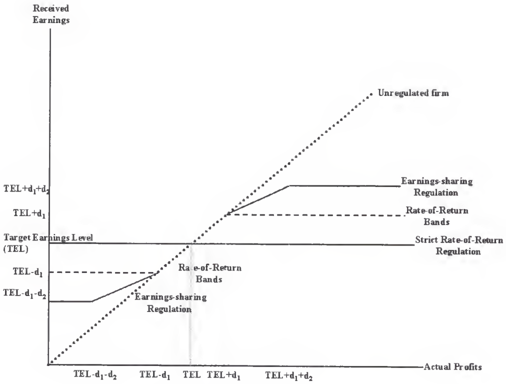

Figure 5-16: Traditional rate-of-return regulation.

Another form of rate-of-return regulation is also shown in Figure 5-16. Banded rate-of-return regulation permits the regulated firm to operate within rate-of-return bands. $TEL+d_1$ becomes the upper band while $TEL-d_1$ is the lower band. Hence, the band size is $2d_1$. Under this policy, rather than attempt to recalibrate prices frequently to deal with inevitable variation in earnings, the firm is permitted to allow earnings to vary within a range set by the regulating agency. Banded rate-of-return regulation allows more flexibility, but suffers from the same problems the strict policy does. When costs are rising, banded rate-of-return regulation gives regulated firms a way to absorb higher costs through price increases [Ai and Sappington, 1998]

Traditional regulatory theory does not end with rate-of-return regulation, though rate-of-return still dominates regulatory practice for rural-certified ILECs. Accounting methods such as fully distributed costs and direct costing are used along with economic methods such as incremental cost to map the regulated firm's cost to a TEL or to a regulated price. Costing methods may be used outside rate-of-return schemes to set prices directly. However, convergence may doom cost-based pricing as Jamison concludes:

> The difficulties of cost-based ratemaking have increased exponentially in recent years. This makes regulators' lives difficult enough by itself, but it is particularly troubling when one realizes that we were unable to resolve cost measurement issues even in the simpler world. [Jamison, 2000, p. 25]

Cost-based pricing schemes or certain demand-based schemes such as Ramsey pricing allowed inefficiencies and abuse of the regulatory process under pre-convergence regulation [Sheehan, 1991]. These effects would be magnified in the conceptual model of hypercommunications presented earlier.

Another set of regulatory devices is known as incentive regulation. Incentive regulation is defined by Sappington and Weisman as follows:

> Until relatively recently, rate-of-return regulation was the predominant form of regulation in the telecommunications industry. Today, alternatives to rate-of-return regulation are commonplace. These alternatives take on many forms and are generally referred to as *incentive regulation*. . . . Incentive regulation can be defined as the implementation of rules that encourage a regulated firm to achieve desired goals by granting some, but not complete, discretion to the firm. [Sappington and Weisman, 1996, pp. 1-2]

The first form of incentive regulation is Earnings Share Regulation (ESR), a variation on rate-of-return regulation (also shown in Figure 5-16). According to Ai and Sappington,

> ESR requires the regulated firm to share realized earnings with its customers according to a specified schedule. The typical schedule specifies an intermediate range of earnings in which no sharing occurs, so the regulated firm's actual earnings vary dollar for dollar with its financial performance in the marketplace. [Ai and Sappington, 1998, p. 5]

An earnings share factor, d_2, is used to construct an earnings share region as shown in Figure 5-16. Sharing occurs from TEL + d_1 to TEL + d_1 + d_2 using

> . . . a fraction (often half) of incremental earnings above (and often below) this intermediate range are shared with consumers. Once earnings reach this bound, the firm does not benefit financially from improved performance in the market

> place, much like RORR (Rate-of-Return Regulation). [Ai and Sappington, 1998, p.5]

All profit above TEL + d_1 + d_2 is given to ratepayers under the ESR plan shown in Figure 5-16 [Sappington and Weisman, 1996, p.111]. However, if profits fall below TEL-d_1-d_2, then rates are revised to allow the firm to earn TEL + d_1 + 0.5d_2 or whatever the revenue share amount would be. Sappington and Weisman say it is rarely a 50/50 split.

Another form of incentive regulation is price-cap regulation. Price-cap schemes are used to price telephone access in Florida for non-rural-certified price-cap ILECs such as BellSouth, GTE, and Sprint. Braeutigam notes that price-cap regulation removes any effort to map accounting or economic cost determinations to prices [Braeutigam, 1997]. Price-caps are meant as a more workable and less inefficient method of achieving a zero economic profit result.

Before considering how price-cap regulation may fare under the conceptual model of convergence in the hypercommunications marketplace, an outline of the status quo's ILEC price-cap regime is in order. According to the FCC:

> Under price-cap regulation, rates charged by incumbent local exchange carriers are governed by caps on rates instead of traditional rate-of-return regulation. Price-cap regulation creates incentives for LECs to operate more efficiently and to introduce innovative new services. [FCC CCB, Competitive Pricing Division, 1999]

Price-cap regulation caps prices using a rate that creates falling prices over time on regulated services. Since firms cannot control the rate of price-cap decline through production costs or earnings, the regulated firm has an incentive to reduce operating costs.

Conceptually, the price-cap is set so that the regulated firm will get zero economic profit. This occurs if "the rate at which its output prices rise on average, is restricted to equal the difference between: (1) the rate at which the firm's input prices rise; and (2) the rate at which the firm's productivity increases." [Bernstein and Sappington, 1999, p. 12] Symbolically this is expressed as CAP = RPI - X, where RPI is an input price index and X represents the x-factor, an average rate of price decline with inflation controlled.

Alternatively, the price-cap on output prices in the regulated industry, can be written as:

$$\dot{P} = \dot{P}_E - \chi_1^b. \quad (5\text{-}2)$$

Here, output prices in the regulated sector $\dot{P}$ are allowed to increase at the rate of output price inflation in the entire economy $\dot{P}_E$ less an offset, the basic x-factor χ_1^b. The cap is composed of multiple goods through a quantity-weighted index that changes yearly.

However, as Foreman discusses, the weights on items a basket of services under a common price-cap can be manipulated by regulated firms. Figure 5-17 (adapted from Foreman, 1995) shows how this can occur.

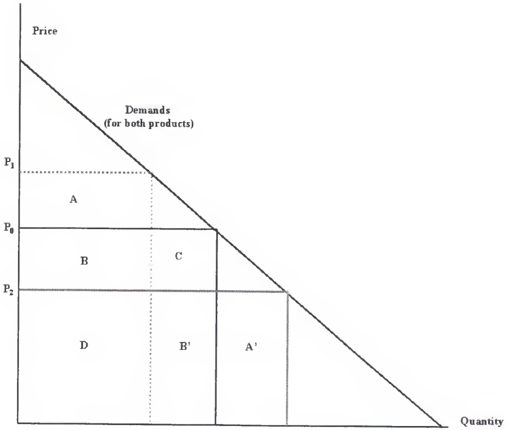

Figure 5-17: Manipulation of price-cap weighting.

Suppose that there are two services, each with the weight 0.5 in the first period and each with an identical demand curve as shown. In the first period, the regulated firm can set each price equal to the cap (exactly) and satisfy the regulation. However, if the firm wanted to raise the price of one service, it would have to lower the price of the other service by an equivalent amount, unless the demand for one service was perfectly inelastic. By increasing and decreasing prices, the firm would lower its profit for the first period compared with the equal price case.

If the price equals p_0 for both products, then total revenue would be 2(BCDB'). Note that if one price is increased to p_1, then the other must fall to p_2. The first service would gain A but lose areas C and B'. The price of the second service would result in a loss of ABC and a gain of A'. Since A equals B and A' equals B', the net loss overall for the firm is 2C. Over time, however, such behavior would become profitable because the weights for the next period would change with prices since they are revenue-based. With a new, lower rate, the regulated carrier would be able to raise profits but stay under the cap. The more inelastic demand is the greater that a firm could use revenue weight manipulation. Quantity weighting would defeat this incentive to cheat [Foreman, 1995]

Another consideration is that for multi-product firms, joint products and non-allocable factors make it impossible to measure RPI or the x-factor for specific products. Thus, adjustment of the x-factor can be sued as a proxy. The adjusted x-factor also corrects for limited regulatory control of multi-product firms. If only some services produced by the firm were regulated, while others were not, then (5-2) would become

$$\dot{P}_C = \dot{P}_E - [x_1^b + x_1^l] = \dot{P}_E - x_2^b. \text{ (5-3)}$$

In (5-3) $x_2^b = x_1^b + x_1^l$, while x_1^l represents an adjustment for a limited span of regulation [Bernstein and Sappington, 1999, p. 19, equation 3.6]. Hence, the cap is flexible enough that the constraint on capped price increases can be relaxed if uncapped service price growth is below the growth rate of all input prices and the total factor productivity growth rate of the firm. Similarly, the growth rate of capped services would need tightening if the reverse were true [Bernstein and Sappington, 1999, p. 21].

There are several disadvantages to price-cap regulation. First, there is the risk that regulated firms will suffer from "excessive or unduly meager earnings." [Bernstein and Sappington, 1999, p. 7] Furthermore, due to regulatory lag and other factors, the choice of an appropriate X-factor can easily miss the socially optimal figure. In addition to the possibility that firms will strategically change revenue weights, there are possible inefficiencies with multi-product firms with only some products regulated. Nevertheless, price-cap regulation is currently an important part of the regulatory arsenal since it seems to be socially preferable to other methods. Overall, incentive regulations have been found to have effects that are more positive on the regulated market and infrastructure development than rate-of-return regulation [Ai and Sappington, 1998]

A third topic is the implication of deregulation on the availability of high-speed access to hypercommunications. Here, several new pricing regulations on interconnection have been designed to increase competition and improve availability and choice. There are two chief objectives: first, to consider how regulation, deregulation, and re-regulation may be used to expand the rural infrastructure; second, to consider how market structure and pricing may be altered as regulation and convergence interact.

Under convergence, this strain of regulatory theory may impact agribusiness hypercommunications by changing interconnection pricing, allowing competitors to use ILEC facilities to provide a range of services over the ILEC local loop or cable TV infrastructure. The ILECs are generally required to allow open interconnection, even with non-telephony services such as DSL. However, the cablecos do not have to provide open access to competing providers over their facilities [May, 1999]

The ECPR (Efficient Component Pricing Rule) is one example of how interconnection is treated by regulators. The ECPR encourages new entrants that want to access an incumbent's network to serve a limited area. Such fringe competitors will not enter unless they are able to profit from wholesale rates that have been set at such a level so that the incumbent cannot bar the new entrant. The ECPR yields an interconnection price paid by the entrant (such as an ALEC) to interconnect with the ILEC's network under the following relationship. The ECPR can be written as:

$$IP = RP - [RC - WC]. \quad (5\text{-}4)$$

Where:
IP is the interconnection price
RP is the retail price
RC is the retail cost
WC is the wholesale cost.

The idea is to pick "an access price equal to the difference between the telephone operator's price and marginal cost on the competitive segment." [Laffont and Tirole, 1996] The IP would correspond to a fraction of VACC and RACC that most closely matched specific marginal costs. In this way, competition would be fostered.

Other related interconnection issues include the difference between resale and unbundling, traffic mix, traffic exchange, and other barriers. The difference between resale and unbundling will become clearer when bundling is taken up in Chapter 6. Essentially, this concerns how prices for providers who use an incumbent network (ILEC, cableco, or electrico) are structured given that some alternative providers have their own transport (or intermediate access) networks while others are purely resellers. The ECPR or another method is used to help set prices on UNE (Unbundled Network Elements). A UNE can be a hardware device or a virtual element of a more complicated composite service.

Within the conceptual model (5-1), the IP (determined through the straight ECPR method) becomes a fraction of the retail costs such as RACC, RTR, VACC, and VTR. With UNE, these prices cannot easily be compared among providers. At the wholesale level, the cost behind each applicable service is broken into as many as several hundred sub-components and priced individually. At retail, the resulting prices may appear comparable, but particular options on a service or class vary. For example, many ALECs use UNE to include so-called custom calling services that require AIN (such as caller ID, call waiting, etc.) in RACC, rather than pricing them as separate services or charging a separate VACC per-use [Jamison, 1999]

Traffic mix rules concern how to recover the underlying costs for a particular type of traffic from a converged network. For example, Chakravorti, Sharkey, and Srinagesh suggest that if each asynchronous ATM cell on a converged network were naively priced (using equivalent regulated voice rates), an arbitrage opportunity would exist. A local telephone call might be $0.01 per minute, but a two-hour video movie (at 45 Mbps) would be priced at $843.75. Even with compression and a T-1 speed (1.544 Mbps), the cost of the movie (again using regulated telephone rates) would be $30.

If the true costs of access and transport in computer networks are used instead, the results are dramatically different. The regulated telephony rate charges a VACC (with VTR embedded) capable of recovering all costs for a circuit-switched connection over the PSTN. Inherently included are the combinatorial, probabilistic, and variation technical characteristics of the telephone network (as explained in 3.3). However, through traffic mix arbitrage (where the market technologies internalize VTR) all costs could be recovered with a fixed price (RACC) of approximately $40 per month [Chakravorti, Sharkey, and Srinagesh, 1995, p. 83]. Arbitrage[25] would be possible because computer networks have more flexible combinatorial, variational, and probabilistic properties than the regulated PSTN. This point was made repeatedly in Chapter 3 beginning in 3.4.1.

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[25] Traffic mix arbitrage offers low risk to service providers. However, for customers, there are many QOS risks that can mean services with fixed RACC and RTR and no variable or traffic-sensitive pricing may under-perform compared with alternatives that have recurring *and* variable pricing. While it may be possible on average to get a video signal from point A to B for $40 a month alone, the overall quality of the service is unlikely to approach PSTN standards. Hence, the "arbitrage" (at this stage of technological development) involves the sale of different goods.

Hence, regulatory prices must be competitive across classes of the conceptual model.

> On a per packet basis, a video packet will likely be heavily discounted relative to a voice packet. Voice signals might then be aggregated and packaged so as to resemble a video transmission, assuming that detection by traffic-distinguishing methods is imperfect. As a result, video channels could be used to carry voice traffic at a price that is significantly lower than that being charged by the local operating company for bulk transport of voice. [Chakravorti, Sharkey, and Srinagesh, 1995, p. 100]

Such inconsistencies can create opportunities for agribusinesses (with access to hypercommunication networks) to buy more communications (measured by capacity and bits) than they otherwise would be able to if access was restricted to PSTN service offerings.

Fourth, and finally, there are concerns about re-regulation necessitated by QOS issues, regulatory jurisdictions, and negative network externalities. While the FPSC does place standards on some regulated services (for example, a POTS line must be capable of sustaining modem speeds of 9.6 kbps), most QOS issues are left for the market to solve. Hence, there may be no recourse for agribusinesses that purchase new voice circuits from ALECs and then find they cannot receive or make telephone calls for several weeks because of a carrier software or hardware problem. The only recourse may be the recovery of charges for the period of time the circuit is down. Without a SLA from the carrier, they may be no guarantee of reliability, speed, or a host of other QOS dimensions. It is conceivable that as the regulatory mission broadens from universal service to universal access, specific performance-based rules (currently enforced on telephones and electric utilities) would be required on wider service classes. However, regulatory authorities are in no hurry to expand their missions.

In Florida, complaints concerning non-regulated hypercommunication services do not go to the FPSC, but to the Department of Agriculture and Consumer Services (DACS). It can be confusing for agribusinesses to understand where to turn if a serious problem arises. In some cases, there is no remedy other than court. For example, customers of the now-defunct Iridium project had no agency to turn to (federal, state, or local) when the carrier went bankrupt. Some customers were saddled with expensive CPE that was incompatible with other providers and lost pre-payments for up to a year of service. The untaxed, unregulated Internet offers many opportunities but also danger. Unlike the PSTN (where prank calls can be traced), there may be no way to catch the cracker that steals company financial data or the vandal that destroys a website.

5.6.4 Asymmetric Taxes and Regulatory Charges

Specifics of the third issue, direct taxation, were discussed in 5.5.2. However, it makes sense to cover the topic briefly in a more general way. By doing so, the tendency of taxation to alter competition among classes and among services in the conceptual model (5-1) can be reduced into a more apparent form. There are four general forms of taxes and regulatory charges. Table 5-16 shows each type, a general formula, and gives an example of each.

Table 5-16: General form of hypercommunication taxes and fees.

General type	Formula	Examples
Ad valorem	$r(V\,Q + R\,U)$	State sales and use tax
Fixed	$F\,U$	SLC, PICC
Tax on taxes and fees	$t[r(V\,Q)+F\,U]$	Federal excise tax, state gross receipts tax
Indirect		Price cap on special access basket.

First, ad valorem taxes are assessed on a percentage basis of the taxable total of RACC, TRT, VACC, and VTR for a particular service. The tax rate, r is multiplied by the taxable prices V or R on quantities (Q or U)[26]. Ad valorem taxes or fees differ in competitive impact only when particular classes (such as Internet access) are excluded entirely, or when they do not appear in a particular cost such as to RACC, RTR, VACC, or VTR.

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[26] The vector V represents prices on a vector of variable units Q so that VQ becomes the cost of VACC or VTR in (5-1). Similarly, R and U are the price and quantity vectors associated with recurring costs RTR and RACC.

Fixed fees or taxes (F) are usually regulatory charges that apply to the units (U) on which recurring access charges (RACC and RTR) are based. Typically, either the units applicable to RACC (such as access lines) or those applicable to RTR (such as pre-subscribed LD lines) are used. In addition to the competitive effect of that distinction, the U or F among classes may differ. For example, the F is different between the single-line PICC cap of $4.35 per line and the multi-line cap of $9.20 per line. U's differ also, as when 23 or 24 derived lines on a T are one unit that is assessed 5F, while two lines are assessed 2F. Recall that charges or taxes may apply only to certain carriers such as ILECs, to certain customer classes, or to particular service offerings only. Hence, they can have an asymmetric impact on different firms as well.

The third example is the tax on a tax (or on a regulatory charge). The federal excise tax, for example, includes the USF contribution, SLC, PICC, and some local charges such as right-of-way and 911 charges. This compound taxation magnifies the effect of such taxes. Taxes on taxes and fees are applied most often to fixed regulatory charges that are transfers from customer to firm under the rationale that these fees are no different from recurring charges.

The last form is the indirect tax or regulatory charge. Indirect taxes and fees tend to differ according to how services are defined within a class or among classes. For certain special access connections for private data networking, federal SLC or PICC charges are incorrectly collected through modifications of the x-factor on local loop-based services that have no ALE or minute conversion unit. Customers may not realize that the price of the underlying service (always RACC or RTR) is slightly higher than it would otherwise be so that ILECs can indirectly collect an access subsidy.

The incidence of taxes and fees, while important, can only be touched on here. In general, the more inelastic the demand, the more the incidence of a tax shifts to buyers. Similarly, the more elastic the supply, the more the incidence is on the buyer. Taken together, the tendency for demand to be relatively inelastic on local access [Taylor, 1994]. and for supply to be elastic (by the cost arguments in Chapter 2), results in the forward shifting of many taxes and fees to customers. Of course, there can be variation among the four forms of taxes and fees. The indirect tax might seem to be easier to pass on to customers (or be backward-shifted to suppliers or employees of the carrier) than a direct tax or charge. However, the post-1996 TCA custom of adding fixed regulatory charges as line items on customer bills (rather than embedding them in prices) suggests it may be easier to pass along an explicit tax to customers rather than an indirect one.

An issue related to asymmetric taxation is the broader concern over asymmetric regulation. It is often argued that asymmetric regulation and taxation produces market inefficiencies on agribusiness demanders and hypercommunications suppliers. However, before presenting that argument, it is important to take the advice of Sappington and Weisman. One of the ten myths of incentive regulation is that "Absent direct evidence of harm caused by asymmetric regulation (that is treating different competitors differently), it is safe to assume that no harm has occurred." [Sappington and Weisman, 1996, p. 333] This warning rings similar to the tendency for some to automatically equate provider size, mergers, or other changes in market structure with automatic losses in social benefits. As Weaver states, "the presence of bigness in a case at hand will convince many lawyers that they will find 'something bad' about the situation if only they look long and hard enough." [Weaver, 1977, p.170] Again, absent evidence of collusion, predatory pricing, or other anti-competitive actions, decreases in firm numbers or other structural changes do not automatically transfer into socially inefficient conduct.

However, it is clearly theoretically possible for asymmetric regulation to create negative impacts on efficiency. Again, possible impacts can be understood through within-class, among-class, and bundle-by-bundle analyses of the conceptual model. Even when an asymmetric barrier is withdrawn, the pre-barrier service structure tends to linger, prohibiting reliability and regional availability.

Importantly, technology is changing at a faster rate than regulation and policy can. This is leading to a new communications market for rural and urban areas as Bernard Courtois writes in 1996:

> Throughout the world, there seems to be an accelerating trend in both developed and less-developed nations toward privatization and more competition. As well, there are numerous consolidations and alliances between players and across national borders and across industry borders. The whole notion of traditional lines of business, where you had various players in their respective little cubicles, is disappearing through these changes. [Courtois, 1996, p. 189]

Importantly, regulatory policies governing hypercommunications need to recognize that the important markets for agribusinesses are communication and information, not transport and access. As if to recognize this, Jamison notes that

> . . . telecommunications is becoming a commodity to be used by information services coming from the publishing, computer, and broadcasting industries. Trying to control information markets by controlling telecommunications markets may result in telecommunications playing only a minor role." [Jamison, 1995, p. 516]

The reasoning expressed above was ahead of its time and is more applicable now for agribusinesses than ever. However, as access and transport become more like commodities, it is hard to see where Florida agribusinesses are left. Regulation appears to have several important effects.

First, agribusinesses have to have competitive high-speed access to hypercommunication networks in order to profit from information and communication. Regulation may help bring high-speed access to hypercommunications networks in rural parts of Florida faster than would otherwise occur. However, far from guaranteeing the universal access standard of the 1996 TCA, the FPSC can only guarantee 56 kbps universal service within several years [FPSC, 2000]. The federal standard of 200 kbps is not even contemplated yet as a possibility by the FPSC.

Hence, the second benefit of hypercommunication regulations to businesses is a perverse one, the arbitrage opportunity arising from using derived channels from competing providers instead of PSTN or ILEC-based carriers. Again, access is needed to obtain this advantage and may not occur for years in the most sparsely populated parts of Florida. Thus, poorly located agribusinesses may become locked into the telephone and enhanced telecommunications network where bandwidth and bps are not yet commodities. However, many mitigating factors such as market competition and the fact that fully converged technologies cannot compete on an equal QOS footing may lessen negative impact.

5.7 Communication and Rural Development Measures Targeted to Agribusinesses

The discussion of how hypercommunications policy affects agribusiness would not be complete without mentioning how rural development policies help rural agribusinesses reach infrastructure development goals. Several state and local rural development programs can directly or indirectly help agribusinesses with hypercommunications. While not a major focus of agricultural policy, the development of rural infrastructure and special programs designed to help agribusinesses with their hypercommunication needs have received some attention.

Some federal programs are designed to support infrastructure development indirectly in rural areas, as part of agricultural policy through the Farm Bill. Some are demonstration programs or other small-scale efforts. Additionally, there are modest state efforts. Some of these initiatives are listed in Table 5-16.

Rural infrastructure development is one of four basic approaches to rural development policy. The rationale for rural infrastructure development was given in 5.4.2. However, federal rural development policy lacks cohesion and is especially splintered in communications infrastructure development (outside of RUS programs for rural-certified ILECs) [Fisher, Harris, Fletcher, and Brown, 1998]

AgVenture Services is a program of Florida's Department of Agriculture and Consumer Services (DACS). AgVenture is designed to promote the use of commodities from Florida agriculture in value-added products, while increasing agribusiness profitability within Florida. While mainly a marketing and promotional program, AgVenture services can help new agribusinesses with facilities and equipment (including hypercommunication-related products) as well as with developing business plans, competitive intelligence, and (in some cases) offers to share the cost of capital improvements.

Table 5-16: Rural, Agricultural, and Communications Policy Agencies.

Agency	Jurisdiction	Key Responsibilities
AgVenture Services	State of Florida	Agribusiness assistance for start-up or new agribusinesses
Crossroads Florida	State of Florida	Rural economic development and workforce program.
Enterprise Florida	State of Florida	Public-Private partnership in charge of economic development.
Rural Utilities Service (RUS)	USDA	Loans and technical expertise for rural-certified carriers (ILECs).
RUS Telecommunication Program	USDA	Administer rural telemedicine program.
SBIR (Small Business Innovation Research)	USDA	Competitive grants to qualified small businesses.
Rural Development	USDA	Rural economic development. Offers loans and grants to rural businesses.

Crossroads Florida is the state's rural economic development and workforce program. Crossroads Florida works in concert with Enterprise Florida, Inc. a public-private partnership responsible for overall economic development in Florida. Enterprise Florida can assist larger businesses with specialized infrastructure needs as part of a business relocation package. Crossroads Florida does not offer specific assistance for infrastructure development.

The RUS is the successor agency to the REA (Rural Electrification Administration) and is acts as a bank and technical resource for rural electric power co-operatives and rural-certified ILECs. Both kinds of utilities are assisted by the RUS with building rural communications infrastructure. Through loans from the RTB (Rural Telephone Bank), the RUS has helped finance ambitious infrastructure development efforts for rural carriers that choose to do so.

Importantly, the need for regulatory help in extending high-speed hypercommunications to rural areas is not universally agreed upon by ILECs. According to the FPSC, the two ILEC service areas in the state with the greatest percentage of loops capable of supporting DSL are Northeast Florida Telephone (100% of DSL-capable loops) and TDS Telecom (formerly Quincy Telephone, 67% DSL-capable) [FPSC, 1999]. The FPSC concludes that no state action is needed to improve outside plants of small rural-certified ILECs since the federal RUS modernization program requirements are taking care of the problem already.

However, such a conclusion ignores the fact that non-rural-certified carriers are hardly rushing to extend high-speed services to the rural areas they serve. Some rural-certified carriers are meeting the federal 200 kbps standard [FCC CCB, FCC 00-290, 2000] of extending advanced telecommunications services, but others have no DSL program. Furthermore, all of Florida's rural-certified ILECs combined serve only 193 thousand customers over a service area that comprises 14 percent of Florida's land area. More importantly, non-rural-certified carriers BellSouth, GTE, and Sprint serve at least ten times as many rural customers (depending on the definition of rural, see Table 5-3) and their actions will have more impact.

If a rural-certified ILEC (or non-rural-certified ILEC) decides not to upgrade its plant and no competitor is able to do it, there is no federal program to encourage deployment of high-speed service other than USF support. However, currently USF support is targeted towards universal service (telephony) instead of universal access (hypercommunications).

Under current regulations, RUS can lend to service providers only to

> . . . meet the 'basic local exchange telephone service needs of rural areas', i.e., provide wireline voice service. This prevents RUS from lending to providers that want to offer, for example, advanced telecommunications services without offering voice. Given Administration and Congressional interest in promoting the availability of broadband, RUS is proposing regulatory reforms to change these policies. This would allow RUS to use more of its $670 million in lending authority for rural telecommunications to encourage private sector investment in rural broadband services. [USDA RUS-NTIA Joint Project Team, 2000, p. 43]

Other USDA agencies and programs concentrate on rural development. Some such as the SBIR (Small Business Innovation Research) makes grants to qualified small businesses to support high technology research and other qualified projects. Agribusinesses can obtain loans or grants from several other USDA rural development programs. These include B&I Direct Loans, B&I Guaranteed Loans, IRP (Intermediary Re-lending Program), RBEG (Rural Business Enterprise Grants), RBOG (Rural Business Opportunity Grants), REDL (Rural Economic Development Loans), and REDG (Rural Enterprise Development Grants). Money from these programs can generally be used to help defray business expenses including communications.

The specific programs in Table 5-16 are not targeted only to agribusinesses or to hypercommunications. However, they do represent sources of funds for small agribusinesses seeking to upgrade the communications infrastructure on their own premises. Loans and grants are often made for capital equipment such as CPE devices.

Chapter 5 has concentrated on the implications of regulation on agribusiness hypercommunications. The topic is an enormous one. The regulatory rationales are wide-ranging, the mechanisms complicated, and the traditional and incentive regulation are not necessarily able to handle convergence. However, three main conclusions can be reached.

First, access to hypercommunication networks is important for agribusinesses and the communities around them. Until universal access occurs, some agribusinesses and some rural areas of Florida will not be able to compete on the same terms with other areas. However, neither the FCC nor the FPSC are ready to expand universal telephone service to high-speed universal access. Of all agencies, the RUS has had the best record of accomplishment of improving service in rural areas. However, the population served by rural-certified ILECs in Florida is small. Furthermore, RUS results depend on the ILEC's initiative, and, even then, are limited to DSL.

In Florida, the most important infrastructure that can be used for access is probably that of non-rural-certified carriers. However, other less regulated providers such as cablecos, and fixed wireless providers are showing some initiative in small towns and rural areas in parts of the state. Technological developments and competition are driving convergence. New, better, and cheaper technologies are being developed to link agribusiness premises over the "last mile" in the local access network to the hypercommunications networks. Regulatory efforts alone are unlikely to result in universal access.

Ironically, where there are multiple forms of access, asymmetric regulatory and taxation produce perverse incentives for businesses to desert PSTN and enhanced telecommunication technologies and use special access, private data networking, and Internet technologies instead for converged hypercommunication needs. Yet, these new technologies are in their introductory stages so that there is a tradeoff between high-tech, low-priced approaches with questionable QOS and low-tech, high-priced approaches with better reliability.

CHAPTER 6
AGRIBUSINESS HYPERCOMMUNICATION NEEDS

> Variations in the scale of production, in rents, and in profits . . . take place from unevenness in the distribution of population, not in the sense of the existence of certain areas where it is on the whole more dense, but in the sense that the *markets of different sellers fit into each other in highly irregular fashion*. [Chamberlain, *The Theory of Monopolistic Competition*, 1936, p. 198, italics mine]

Although they were written sixty years ago, Professor Chamberlain's remarks fit what Florida agribusinesses face today as the four legacy communication markets (telephone, enhanced telecommunications, private data networking, and Internet[1]) converge into one hypercommunications network. Variations in profits and the scale of production are apparent in differences in the availability, service quality, and pricing of hypercommunication network access throughout Florida. For example, in downtown Miami, more than fifty competing carriers (with six competing infrastructure technologies) offer many kinds of high-speed access for voice, data, and Internet. However, in other places, choice is restricted to a single ILEC that offers POTS (Plain Old Telephone Service), barely capable of supporting 28.8 kbps modem transmission over analog lines.

Population density alone does not explain such differences in production scale or the enormous variation in profits and pricing. In short, the hypercommunications marketplace in

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[1] Full details of these four markets are found in sections 4.6 through 4.9.

Florida fits Chamberlain's pattern of "markets of different sellers" that "fit together in highly irregular fashion". Chamberlain's original analysis applied to the location problem where retail or wholesale customers travel to a seller's store to shop and buy. Sellers had two economic objectives. The first objective was to select the best store locations given a specific density of customers. The second objective was to discover what product mix would maximize the sales and profits of each location. Customers, in turn, would be "pulled" into visiting the store with the best combination of location and product mix.

In hypercommunications, since a physical wireline circuit (or wireless path) is required, the store location problem becomes a POP (Point of Presence) location problem with additional complications. Bandwidth (communication capacity), data rate (communication speed), and QOS (communication quality) are directly delivered to customers. Figure 6-1 illustrates this by showing the organization of Chapter 6 and Chapter 7 and their interrelationship.

Two parts of the figure come from material presented in earlier chapters. The QOS reference model (at the top) and the conceptual model (at the bottom) weave a context for Figure 6-1 so that the organization of the chapter into five sections is easier to follow. The QOS reference model (from Figure 4-14 in 4.2.3) separates hypercommunications into access, transport, and CPE (Customer Premises Equipment) at agribusiness locations one and two[2].

The access level is an electronic pipeline that has been (or has to be) built from a transport carrier's POP to each customer (or cluster of customers) in the form of wires, cables, or wireless transmission equipment. The transport level transmits large amounts of information over long distances at low cost to the POP that serves the second agribusiness location. All forms of hypercommunication (telephone calls, e-mail, faxes, data, enhanced telecommunications, and

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[2] Two locations are shown to make market boundaries, bundling, and prices easiest to understand. In general, an agribusiness may establish a hypercommunication network to communicate with many of its own locations as well as with others who have access to the network.

Internet traffic) travel from the sender over an access level, through a transport network, and over another access level to reach the recipient. This is also true when location #2 is a customer or vendor instead of another office. Note that each agribusiness location uses a separate access level based on the access technology and location to reach the transport network.

The POP connects the physical access level (usually built and operated by a specialized carrier called an access provider) with a physical and virtual transport level or carrier network (often operated by another carrier). Open access from any access provider to any competing transport networks can encourage competition at the access level (leading to more and better communications being sold for successively lower prices) as the section on positive network externalities (3.7.2) suggested. However, as the section on negative network externalities (3.7.3) also suggested, unless the costs of the access level are somehow recovered, open access can lead to congestion and other costs not reflected in market prices. Hence, hypercommunication sellers (such as access providers and transport carriers) cannot simply build stores and recover costs when customers visit, they must build an infrastructure to the customer, recovering their costs through an installed customer base.

Recall from Chapter 2 that the hypercommunication network combines the mass and interpersonal communications models into a mesh network that can carry messages ranging from telephone calls to live video auctions. For convergence to occur, two things must happen. First, high-speed, high-capacity access loops must be available to connect users to POPs that second, are capable of replacing the old separate transport networks of the PSTN (Public Switched Telephone Network), the Internet, and private data networks. In the simpler retail store example, buyers pay a cost in time and money to travel to a store that is optimally situated from the store's point of view. However, hypercommunication access providers and transport carriers incur costs of physically connecting to their customers.

However, a transport carrier need not build the costly access level itself to connect prospective customers with its POP. Cooperation between two hypercommunication firms (an access carrier and a transport carrier) may be required to build a communications path to a prospective customer.

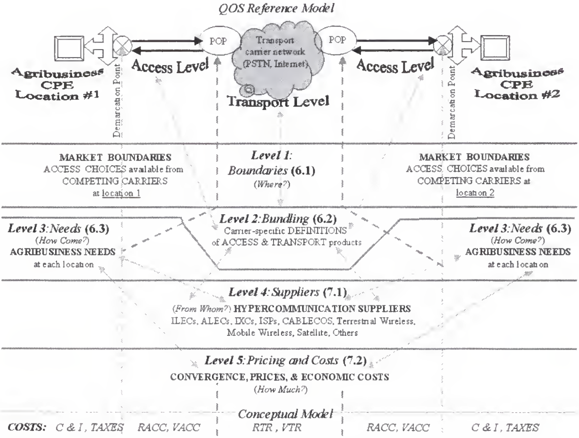
QOS Reference Model
POP
Transport carrier network (PSTN, Internet)
POP
Agribusiness CPE Location #1
Demarcation Point
Access Level
Transport Level
Access Level
Demarcation Point
Agribusiness CPE Location #2
MARKET BOUNDARIES
ACCESS CHOICES available from COMPETING CARRIERS at location 1
Level 1: Boundaries (6.1)
(Where?)
MARKET BOUNDARIES
ACCESS CHOICES available from COMPETING CARRIERS at location 2
Level 3: Needs (6.3)
(How Come?)
AGRIBUSINESS NEEDS at each location
Level 2: Bundling (6.2)
Carrier-specific DEFINITIONS of ACCESS & TRANSPORT products
Level 3: Needs (6.3)
(How Come?)
AGRIBUSINESS NEEDS at each location
Level 4: Suppliers (7.1)
(From Whom?) HYPERCOMMUNICATION SUPPLIERS
ILECs, ALECs, IXCs, ISPs, CABLECOS, Terrestrial Wireless, Mobile Wireless, Satellite, Others
Level 5: Pricing and Costs (7.2)
CONVERGENCE, PRICES, & ECONOMIC COSTS
(How Much?)
Conceptual Model
COSTS: C & I, TAXES
RACC, VACC
RTR, VTR
RACC, VACC
C & I, TAXES

Figure 6-1: Organization of Chapter 6 and Chapter 7 with interrelationships between chapters.

An important feature that carries through the figure from top to bottom is the demarcation line that separates CPE owned by the agribusiness from carrier equipment. The demarcation line represents the end of the agribusiness' local network and the beginning of the access level (also called the local loop or last mile). Again, the hypercommunications marketplace differs from the store location example because (in addition to the access provider and transport carrier), the agribusiness must make an investment of its own before it can buy access or transport.

The bottom line in Figure 6-1, labeled COSTS is the conceptual model (Equation 5-1 from 5.6.1). Agribusinesses pay several separate costs for hypercommunications as described by the variables of the model shown: C&I, TAXES, RACC, VACC, RTR, and VTR. C&I stands for the cost of CPE and installation for the equipment needed by an agribusiness to hypercommunicate. C&I normally includes hardware, software, and services on the agribusiness' side of the demarcation line. Access level costs are divided into RACC (Recurring Access Costs) and VACC (Varying Access Costs). Similarly, transport costs are divided among RTR (Recurring Transport Costs) and VTR (Varying Transport Costs).

Recurring costs are most often charged on a monthly basis and are classified as NTS (Non-Traffic Sensitive) since they do not depend on the amount of hypercommunications traffic generated by the agribusiness. Varying costs are TS (Traffic Sensitive) and may be incurred on minutes, kbps, or other units. TAXES include ad valorem, per unit, indirect, and compound taxes and regulatory fees as specifically described in 5.5 and more generally covered in 5.6.4. TAXES may apply to any of the other costs. However, because they depend on the service location of the agribusiness, they are shown with the C&I cost on the agribusiness side of the demarcation line.

Three of the five levels between the QOS reference model and the conceptual model form the sections of Chapter 6. The first, market boundaries (6.1) are specific to each agribusiness' location. The market boundary for a given location represents the choices an agribusiness has from competing carriers for access to hypercommunication networks. Market boundaries answer the question of *where* access to high-speed hypercommunication network is available. The section shows how regulatory factors and technology-based infrastructure differences (telephone, cable, and fixed wireless technologies have different ranges from customer to POP) combine to create thousands of different local markets in Florida.

The second level, bundling, is covered in 6.2. Linkages among levels are shown throughout Figure 6-1 to underscore the point that access costs and transport costs may be combined under certain bundles with certain carriers, but priced separately for others. Bundling refers to how access, transport, and other hypercommunication services are often defined as composite goods and priced accordingly. Since hypercommunications is such a complicated subject, bundling can be used to simplify decisions so customers do not get lost in minutiae. However, in practice, bundling also can make comparisons between technologies or among carriers more difficult.

The third level in Figure 6-1 focuses on the unique hypercommunications needs of agribusinesses, contained in 6.3. Specific communication needs are behind the agribusiness manager's question, "*How come* my agribusiness needs hypercommunications?" The diversity of products handled by Florida agribusiness, an agribusiness' position in marketing channels, span of control, and desire to do business globally are sources for many differences in "W*ho?*" needs hypercommunications the most among agribusinesses. Many of the reasons for agriculture's uniqueness are sources of communication needs as well.

The fourth level of Figure 6-1 concerns hypercommunication suppliers. Hypercommunications supply depends on the number, size, and channel position of firms, the conduct and performance of industry players, and regulation. Questions such as "*From whom?*" an agribusiness should buy and "*When?*" to change carriers or upgrade CPE to take advantage of converging networks are answered in an agribusiness' choice of hypercommunication suppliers. Details such as "*When?*" a particular service will be available, and "*Who?*" (among hypercommunication suppliers) will offer it to a particular location are not easily answered on a statewide basis. Suppliers are covered in section 7.1 along with general guidelines agribusinesses can use in evaluating hypercommunication suppliers.

Section 7.2 (the fifth level) considers convergence, prices, and *economic* costs to analyze the question of "*How much?*" an agribusiness should pay for hypercommunications. Specific pricing details for services and technologies change so rapidly and depend so much on competitive pressures in the local markets that too detailed an analysis would become rapidly outdated and could never cover every geographic area. Thus, 7.2 will give broad ranges of accounting prices and make a special effort to discuss certain less obvious (but perhaps more important) economic costs through the conceptual model and an accompanying decision tree.

Technical details that have been left out of Chapter 6 (to retain an agribusiness focus) may be found in other chapters. Because of the complexity of hypercommunications, readers may have to consult technical details in Chapters 3 or 4 or be at a disadvantage. Understanding pricing also depends on an understanding of the asymmetries of taxes and regulatory charges (as discussed in Chapter 5) which can total thirty percent of the bill (or higher) for some hypercommunication services. A key to abbreviations and acronyms is provided to help with the alphabet soup of acronyms and a glossary to help with the sea of jargon that accompanies making business decisions about hypercommunications.

6.1 Boundaries Within Florida's Hypercommunication Marketplace

Boundaries define markets. As an agribusiness shops for hypercommunication services, one of the most important tools for decision making is to understand how markets are physically defined.[3] Boundaries are important because in order to buy with hypercommunications, two things must occur. First, sellers must bring services to buyers via an infrastructure, called the access level in Figure 6-1. Second, buyers must have their own infrastructure (CPE) that is compatible with the seller or carrier's network and capable of handling traffic at every agribusiness location. An agribusiness may do business at fixed locations such as branch offices, or warehouses, as well as in nomadic or mobile locations such as fields, customer locations, salespeople's homes or cars, and trade shows. Locations can be in Florida, national, or international.

Since sellers must bring services to buyers various boundaries are set by technology, government, and competition among carriers. This results in the compartmentalization of Florida's hypercommunications market in practice although in theory convergence should eliminate many boundaries. As Mark Jamison mentions " . . . basing communications policies on boundaries --- whether they be geographic, technological, or something else --- isn't sustainable. And changing the boundaries is often politically difficult if not impossible." [Jamison, February 1997, p.1]

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[3] The market boundaries for many agribusinesses are being changed by hypercommunications, a subject that is returned to in 6.3.

The Internet is a good example of how new technologies are altering traditional boundaries as Werbach notes:

> Governments act by drawing lines, such as the jurisdictional lines that identify which governmental entity has jurisdiction over some activity, or the service classifications that differentiate which body of law should be applied in a particular case. Governments traditionally determine the treatment of new services by drawing analogies to existing services. . . . There are reasons to believe that a simple process of drawing analogies to traditional services will not be appropriate to the Internet. The Internet is simultaneously local, national, and global, and is almost infinitely plastic in terms of the services it can support. [Werbach, 1997, p. 26]

However, this quotation applies to the Internet at the transport level, not at the access level. [4]

Furthermore, Werbach is speaking of regulatory boundaries rather than technical boundaries. Hypercommunications boundaries are of two main types, technical (6.1.1), and regulatory-political (6.1.2). Technical and regulatory-political boundaries (combined with competition for territory by different carriers) create the irregular market boundaries (6.1.3) faced by Florida agribusinesses.

6.1.1 Technical Boundaries

Technical boundaries are based on the underlying transmission technology, electrical engineering, and laws of physics. Technical boundaries affect the transport, access, and CPE levels in the QOS reference model (top, Figure 6-1). Many technical boundaries were covered in Chapter 4. These include wireline conduit ranges (Table 4-7), network protocol efficiencies

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[4] A recent FCC report concluded that (even if interstate, intrastate, and international Internet traffic could be segregated) regulation of the Internet backbone market was not likely to be necessary [Kende, FCC OPP, OPP Working Paper 32, 2000].

(Table 4-27), signal conversion and transformation (Figure 4-2), properties of the electromagnetic spectrum (Figures 4-30 through 4-34), and the range of T-1 line codes (Figure 4-44). While the Internet, fiber optic conduit, and other technologies have led to greater flexibility in boundaries at the transport level, methods of network access must still obey the laws of electrical engineering and transmission[5] that create technical boundaries. In general, technical boundaries depend on the carrier and the carrier's equipment, service type, and the agribusiness' CPE.

Technical boundaries vary by the type of access technology as implemented by a particular carrier. This statement can be supported by showing typical coverage areas for several kinds of technologies: mobile 3G (Third Generation) wireless, fixed upperband wireless, wireline DSL, cableco service areas, fiber optic routes, and Internet tier-one connection locations. Examples of several kinds of these technical boundaries are shown in Figures 6-2 through 6-8.

The first coverage area, shown in Figure 6-2, is for two-way GSM mobile 2G wireless in the Tallahassee area [FCC 00-289, 2000, Appendix H]. Note that the very darkest areas (four distinct sites ringing Tallahassee) are enhanced coverage zones where high two-way data rates are supported for mobile users, while the lighter areas support basic mobile telephone service only. Wireless Internet access and two-way data rates of 384 kbps to 1.5 Mbps can be obtained only in the darker areas shown. Users in outlying areas, shown in moderate gray are able to use only mobile telephony service rather than two-way text and data communication. Even further out, in the lightest gray areas, no service is obtainable at all from the company.

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[5] See sections 4.2 through 4.4.

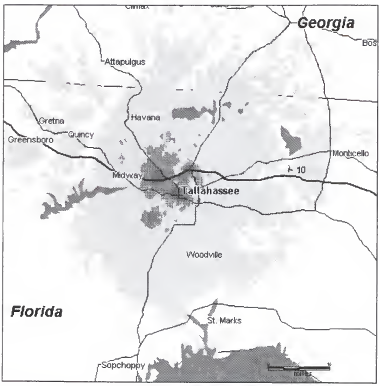

Figure 6-2: Mobile two-way 2G wireless coverage in Tallahassee area.

Two-way high-speed paging coverage areas for Arch Communications in South Florida are shown in Figure 6-3 [FCC 00-289, 2000]. With the exception of Lake Okeechobee (dark gray), other dark gray areas are extended service areas where two-way pager users may send and receive text and voice pages from anyone with e-mail or POTS service. However, in lighter gray areas, only basic one-way paging is available. Service is not available at all in white areas.

The next technical boundary shows the range of two-way fixed wireless. In this case, the system is the Airwire MMDS system as implemented in the Orlando-Space Coast area as shown in Figure 6-4 [FCC 00-289, 2000]. Figure 6-4 shows varying degrees of MMDS coverage intensity. The darker the circle, the better MMDS coverage is. For example, users in Palm Bay and Indian Harbor Beach (dark areas) obtain higher data rates and better system reliability than do users near Sanford or northwest of Titusville (lighter areas).

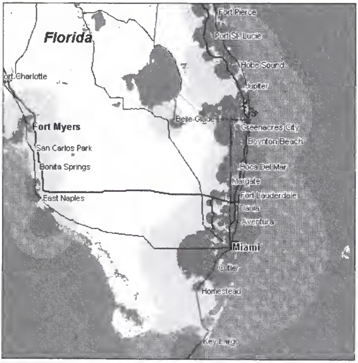

Figure 6-3: Two-way paging coverage areas.

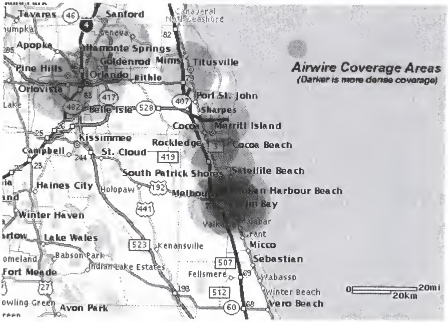

Figure 6-4: Two-way fixed wireless coverage boundaries.

Wireline DSL coverage areas are within telco exchange boundaries as Figure 6-5 shows [FPSC, 2000]. Figure 6-5 can be easily misconstrued. While the figure shows (in white) the BellSouth telephone exchanges where ADSL is supported by CO equipment, there is no guarantee that a particular subscriber located in the white area could actually receive DSL. Successful deployment of DSL depends on numerous technical factors such as loop qualification, loop conditioning, absence of bridged taps and loading coils, and distance from the CO as mentioned in 4.7.3.

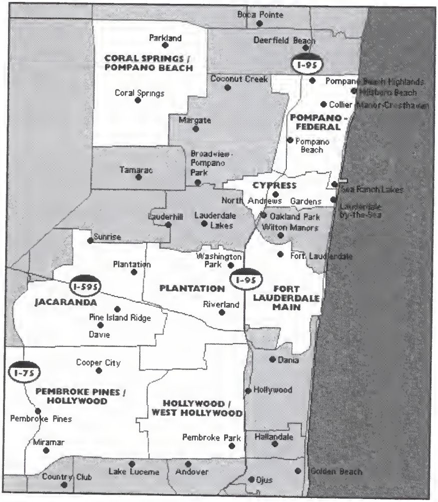

Figure 6-5: BellSouth DSL coverage areas are smaller than the exchange boundaries shown.

Figure 6-6 shows yet another kind of boundary, the service area of two-way digital cable modem and telephony service by MediaOne (now AT&T Cable) in the Jacksonville area [FPSC, 2000]. Locations shown in gray are those in which two-way cable-based access to "broadband" services are available as of March 2000. Cableco service areas are generally determined by franchise agreements made with local governments both incorporated areas and un-incorporated county administrative regions. Often, ADSL and two-way cable service rollouts attempt to compete for the same geographical market area. However, because cable service areas and telco exchange boundaries overlap (but are not geographic equivalents), market boundaries can become splintered.

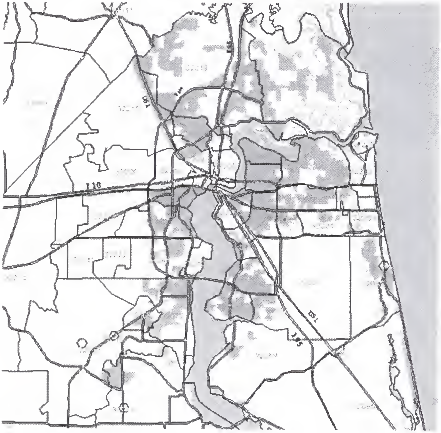

Figure 6-6: Two-way cable modem serving area, AT&T Cable (Jacksonville).

Figure 6-7 (from the Desoto County Economic Development Office) shows the high-speed fiber optic infrastructure laid by Sprint in Southwest Florida. The dark line shows the location of the Sprint high-speed fiber optic conduit. Note that Arcadia, Florida happens to be one smaller community through which the fiber optic cable runs. Consequently, economic development efforts for the City of Arcadia area are able to stress the community's closeness to state-of-the art hypercommunications connections as a method of enticing business to the area. Other nearby areas such as Venice, Port Charlotte, and Sebring do not have a direct route through their communities.

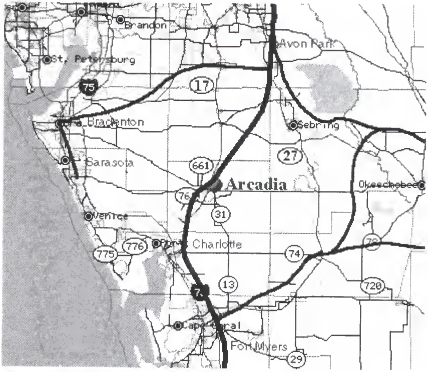

Figure 6-7: Sprint fiber optic route in Southwest Florida.

Another kind of boundary concerns the location of Tier-1 or NSP Network Access Points (NAPs) in Florida. Figure 6-8 shows the location of UUNET's (WorldCom) 45 Mbps national backbone hubs [WorldCom, 2000]. In Florida, four places (Miami, Orlando, Tampa, and Jacksonville) are shown as nodes (local hubs) on the UUNET transport level backbone. Tampa and Miami are multiple hub cities. Lines leading from Miami and Orlando offer direct service to the San Juan, Puerto Rico hubs. Atlanta, Dallas, and Houston serve as regional hubs. Indeed, as will be discussed in 7.1.4, many other providers offer major nodes for Internet access in Florida.

While most are not located in rural areas, the choice of communications carrier can be important based on how closely linked to the Internet backbone that carrier is.

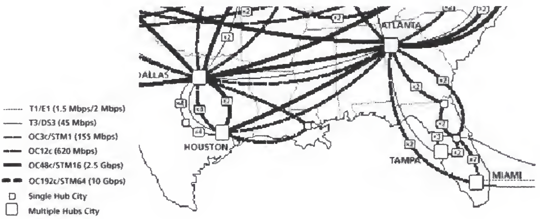

Figure 6-8: Florida's four UUNET NAPs.

Figure 6-7 and Figure 6-8 show the location of what are normally considered transport level connections, the location of which traditionally have mattered only to carriers or extremely large agribusinesses. However, fiber optic conduit is used increasingly to bypass access connections (thus eliminating access level costs) or for access to high-speed services such as SONET dedicated connections (Table 4-29). Therefore, as the proximity to NAPs or fiber optic routes grows in importance, their locations will create new technical boundaries.

Although technical boundaries can arise from geographic features, most of the technical boundaries shown in Figures 6-2 through 6-8 are based on the implementation schedules of particular carriers and on general engineering and technological progress. None are static since they can change rapidly with technological changes, new competition, and mergers. It is important to realize that each carrier offers a different coverage area so that those shown in Figures 6-2 through 6-8 are examples of individual carrier boundaries. The set of technical boundaries for all carriers over all access technologies is much larger.

6.1.2 Political and Regulatory Boundaries

The subject of boundaries would not be complete without mentioning political boundaries and boundaries resulting from a mixture of technical and regulatory reasons. Many regulatory boundaries are a direct result of the way telephone service was originally delivered and regulated. For BellSouth (and to a lesser extent other carriers) regulatory boundaries based on telephone technical boundaries from the 1930's are present today in the regulatory boundaries used for POTS (4.6), enhanced telecommunications (4.7), and private data networking (4.8).

In Chapter 5, Figure 5-5 showed the ILEC coverage areas of Florida to underscore the important role that arbitrary divisions (typically begun in the 1930s and finished in the 1970s) play in the delivery of hypercommunications. In most rural areas, the ILEC has a significant competitive advantage over other carriers based on its traditional status as a monopoly. Figure 6-9 shows the service areas of ILECs by county in the 904 area code [FPSC, 1999].

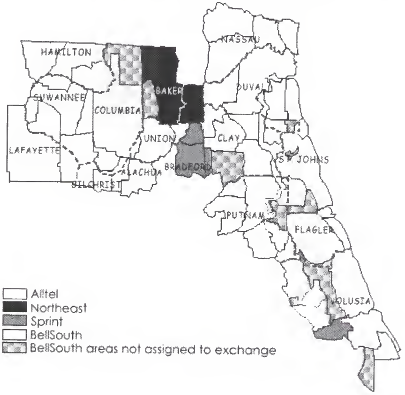

Figure 6-9: Service areas of ILECs in 904 area code.

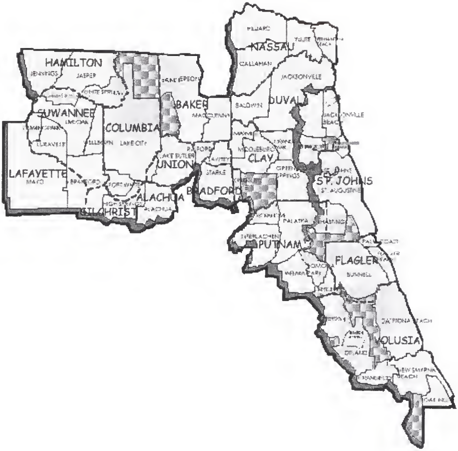

Figure 6-10: Rate centers in area code 904 cross both city and county borders.

Inside each ILEC service area in Figure 6-9 are separate telephone rate centers (used to price long-distance calls and define local calling areas) as shown in Figure 6-10 [FPSC, 1999]. It is important to note that rate center boundaries may cross both city and county lines. For example, the Branford, Florida exchange (located northwest of Gainesville) includes parts of Suwannee, Lafayette, and Gilchrist counties. In urbanized areas, rate centers may include multiple cities. For example, the Daytona Beach rate center includes incorporated areas such as Daytona Beach, Holly Hill, Daytona Beach Shores, and South Daytona as well as part of unincorporated Volusia County. Rate centers were defined by the FCC, the FPSC, and telephone companies (originating with AT&T and ending with today's ILECs). While rate centers are becoming obsolete as the transport level changes from a traditional circuit-switched PSTN orientation to a packet-switched computer network orientation, they are still widely used to price long-distance calls and point-to-point data circuits. They are also used to define local telephone service calling areas (as was shown in Figure 4-36).

Each rate center has one (or more) exchanges or wire centers that form the technical boundaries of ILECs. Each exchange has at least one NNX (telephone prefix) that is allocated among various hypercommunications needs like residential telephone service (subsidized by business telephone service), cellular, PCS, dial-up Internet access lines, fax machine lines, and one and two-way pager lines. The Jacksonville rate center (like others in urban areas) is actually a collection of exchanges shown in Figure 6-11 [FPSC, 1999]

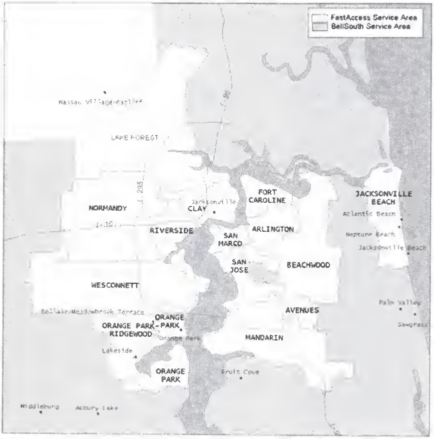

Figure 6-11: DSL availability depends on telephone exchange boundaries.

In Figure 6-11, the exchanges shown in white have DSL available from BellSouth. By comparing Figure 6-10 to Figure 6-11, it can be seen that not every exchange in the Jacksonville rate center has DSL availability. Exchange and rate center boundaries were established for telephony, but the boundaries for DSL (an enhanced telecommunications service used both for Internet access and telephony) effectively depend on regulatory boundaries designed from telephony regulation.

Figure 6-12 shows two additional kinds of boundaries (LATAs and area codes) that affect ILECs, ALECs, and IXCs [FPSC, 2000]

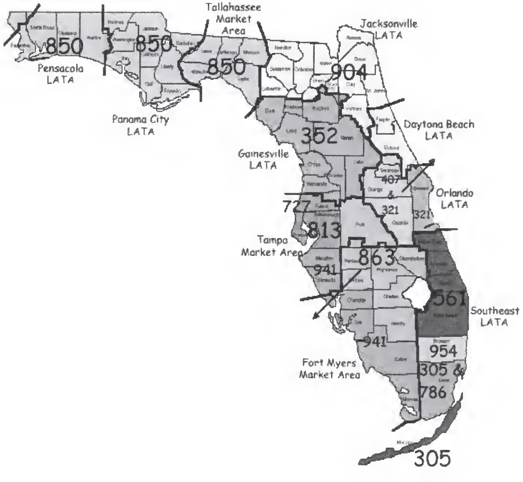

Figure 6-12: Area codes and LATAs in Florida.

Florida's LATAs can be seen in Figure 6-12. They include: Pensacola, Panama City, Tallahassee, Jacksonville, Gainesville, Daytona Beach, Orlando, Tampa, Fort Myers, and the Southeast LATA (Vero Beach to Key West). Minor portions of the Savannah, Georgia and Mobile, Alabama LATAs are also within Florida borders. LATAs were designed as part of the 1984 breakup of AT&T, based on telephone exchanges and rate centers. Based on that agreement (and also according to the 1996 TCA), some carriers are allowed to carry voice, enhanced telecommunications, and data networking traffic between LATAs, while others such as Bell South are not. Firms that compete with these ILECs are permitted to carry such traffic. Furthermore, rates on many services are regulated between LATAs in a different way than traffic within LATAs. Within each LATA are a series of EAEAs (Equal Access Exchange Areas) designed to facilitate interconnection among competing carriers. Area codes (NPAs) are shaped by a combination of regulatory policy and the expected teledensity of an area.

Wireless services follow other kinds of regulatory boundaries from the FCC. Licenses for wireless communications carriers cover mobile services (such as cellular telephony, PCS, and SMR) as well as fixed services (such as MMDS, LMDS, DEMS, and WLL). Each carrier requires a license from the FCC to serve specific territories. Depending on the type of service, FCC rulings may allow one or more carriers the right to serve a specific territory. Often, auctions are used to assign licenses in new spectra to accommodate new wireless services. Figure 6-13 shows the layout of one such territorial boundary in Florida, the eighteen BTAs (Basic Trading Areas) in which licenses for MMDS, Narrowband PCS, Broadband PCS, and LMDS carriers are assigned [FCC, 00-289, 2000]

Other FCC wireless boundaries in Florida include 29 CMAs (Cellular Market Areas) used to grant cellular licenses in, 4 MTAs (Major Trading Areas) used to assign SMR licenses, and 9 BEAs (Basic Economic Areas) used to assign 220 MHz services [FCC, OET, 1999]. However, the right of a wireless carrier to operate within a particular FCC area is no guarantee that the carrier's coverage area will fill that coverage area. To do so, the carrier must construct a series of towers (along with paying the appropriate right-of-way fees to county and local governments) to inaugurate service over the widest area possible.

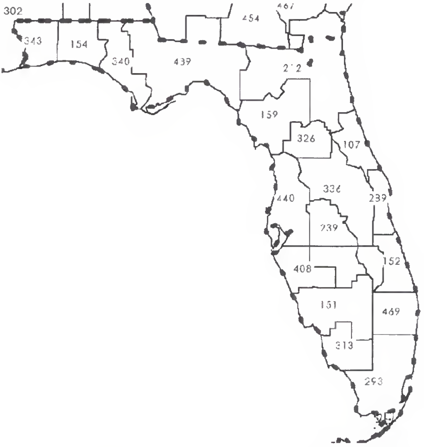

Figure 6-13: FCC BTAs define wireless licensing areas for MMDS, LMDS, and narrow and wideband PCS.

Finally, it is important to consider purely political boundaries. In Florida, there are 67 counties and 398 incorporated places. Incorporated places are city or town governments with their own police, fire, and other city services, along with several regulatory functions in hypercommunications as given in Table 5-10.

Figure 6-14 shows 28 incorporated areas in Broward County in 1997 [Broward Association of Governments, 1998]. Pure white denotes unincorporated areas. Each area is able to assess local taxes, franchise fees, and other regulatory charges as well as determine which cable television and wireless providers will earn a franchise to provide service. Many incorporated areas have annexed areas of relatively sparsely settled land on the edge of suburbia while certain poorer, longer settled areas contiguous to urban areas of Fort Lauderdale remain unincorporated. Some counties have only one or two incorporated areas, but in fast growing, urbanized areas of other counties, dozens of new jurisdictions have sprouted after 1970. One of the main effects on hypercommunications of local political boundaries is that each local jurisdiction may award a wireline cable television franchise to serve that area. Typically, the proportion of the total franchise area where high-speed access is deployed depends on the cableco's agreement with the local government.

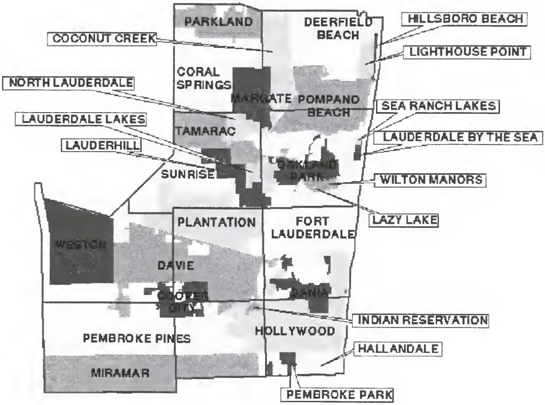

Figure 6-14: Incorporated and unincorporated areas of Broward County.

Therefore, political boundaries affect hypercommunication market boundaries in two chief ways. First, a carrier is given the right to provide access to services through the cable TV infrastructure (including telephone, Internet access, private data networking, and enhanced telephony).[6] Second, local taxes are set based on local jurisdictions.

6.1.3 The Meaning of Market Boundaries to Two Agribusinesses

The impact of this patchwork of regulatory and technical boundaries on agribusinesses becomes apparent when the sheer number of different areas is considered. The unique hypercommunications market that a location is in is a function of how the various boundaries described overlap, along with the number of competing firms that operate within them.

Figure 6-15 explains this point graphically by considering two different agribusinesses, Online Inc. and Offline Corp. Before considering the impact on these businesses specifically, the five kinds of boundaries in the figure need explanation. The first boundary shown is the ILEC territory, shown as a horizontal dotted line near the top of the figure. In the figure, ILEC territories are divided between two ILECs: BellSouth and GTE. Next, within each ILEC's territory are several exchange (rate center) boundaries. Availability of many services and prices for others are based on the exchange boundaries. There are five such boundaries in all shown in Figure 6-15.

Third, the bold star (in three of the rate centers) is the CO for that exchange. A circular area around the star shows the distance limit for deployment of DSL (and other DSL-based products such as HDSL T-1's). Customers must be located inside of the circled area[7] to be eligible to receive DSL. Fourth, there are boundaries of City A and Town B. These boundaries define the coverage area for the cableco. If high-speed access is offered by the cable franchise in either location, assume that it must be within the boxes shown[8]. Fifth, the solid vertical line separates County 2 from County 1. Finally, the solid lines that run from one CO (star) to another show the location of high-speed fiber optic conduit. The location of such high-speed lines is important because high-speed network access can sometimes be bypassed for customers on such main lines but must be kept extremely short if the carrier is to build fiber to the agribusiness location.

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[6] Section 4.3.3 covers different types of cable access networks.

[7] In reality, DSL distance limitations are based on wire length and DSL variety rather than the straight-line distance from the CO. See Table 4-21 and the surrounding text in 4.7.3 for more details.

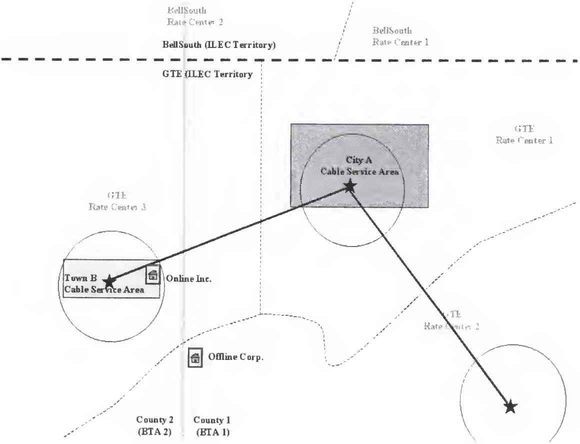

Figure 6-15: Example of how market boundaries affect agribusiness hypercommunications access.

Online Inc. will be faced with a different set of prices and choices than Offline Corp. because of the way boundaries overlap. Online Inc. may obtain DSL and HDSL T-1 services from GTE and any ALECs (and ISPs and IXCs) who serve Rate Center 3. Although Online Inc. is on the outer edges of Town B, it may also get service from the cableco. In addition, Online Inc. is close enough to the fiber optic lines that it could use "on net" high-speed fiber bypass services such as SONET or T-3 circuits if it required (and could afford) the capacity. Offline Corp., located just a few miles away, can rely only on the access network provided by GTE to its location, which is too distant from the serving CO to receive most high-speed services. Each firm is in a different BTA, a fact that could create additional competition in both cases if a wireless carrier chose to extend service to these areas. It should be apparent that Offline Corp. has a locational disadvantage where hypercommunications are concerned.

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[8] In many cases, the cable service area will enter unincorporated areas near incorporated areas. This is usually only profitable when the same carrier serves both areas.

The number of different markets for hypercommunications in Florida is staggering. While not every area is independent of every other, the 461 telephone rate centers, 13 BTAs, 865 active cable TV franchise areas, and 29 CMAs make almost 1,400 different technical, regulatory, and political areas. That is without considering ISP and IXC POPs, ILEC service areas, or the influence of LATAs. Furthermore, the number of possible carriers who may decide to serve a particular location can be large or zero. For example, the 425 ALECs that serve Florida may do so in any telephone exchanges they wish where they have interconnection agreements with ILECs or IXCs [FPSC, August 9, 2000]

While ILECs are required to provide telephone service to every reasonably situated customer within their territories, they have no clear legal requirement (or in some cases permission) to offer enhanced telecommunications or broadband services. In fact, if the former local telephone monopolies concentrate their increasingly stretched resources on building rural infrastructure, they may lose even more ground to new competitors in profitable high teledensity areas. These competitors, who do not have the COLR (Carriers of Last Resort, see 5.5.3) obligations of the ILECs to provide universal service, find a market niche "skimming" off the monopolist's most profitable customers in the cities.

The hypercommunications market in Florida is a classic example of one where "markets of different sellers fit into each other in highly irregular fashion", to quote Chamberlain again [Chamberlain, 1936, p. 198]. However, regardless of market boundary, before a good or service can be priced, the units of price must be defined. Deciding on units is no easy task for hypercommunications as the next section shows.

6.2 Bundling and Other Units of Hypercommunications

Bundling can make understanding the units of in a hypercommunications transaction difficult or easy. Recall that bundling was one of the twelve essential terms introduced in section 1.1. While it is the last to be introduced, it is hardly the least important. Bundling arises now because the economic, technical, and regulatory foundations are out of the way. As convergence occurs, hypercommunications will be sold in bundles of composite goods rather than as separate items such as telephone calls or megabytes of data.

6.2.1 Hypercommunications Bundling

Hypercommunications services can be sold alone (un-bundled) or grouped together in a bundles of services. Bundling may be done for customer convenience, internal billing purposes, due to regulatory edict, to prevent direct price competition or otherwise confuse customers, or in an attempt to protect a supplier's incumbent (or monopolistic) position. The hypercommunications bundle is the quantity that prices are based on.

For example, a local telephone call includes many individual services. These include: the type of access loop wiring, dial-tone, switching, ringing, access level transmission, transport level transmission, busy signal, circuit establishment, connection maintenance, etc. If each component of a call was included separately on the bill for every local call, one call would result in many entries on a subscriber's monthly bill with a separate price for each one. Business telephone bills can already add up to hundreds of pages, but un-bundling every item on every local call would exponentially increase bill sizes. When a technical set of services is too complex for customers to understand in detail, bundling can help buyers understand the general nature of services without confusing them with minutiae. As with restaurant menus, ordering *a la carte* will still be available but more expensive. The transaction costs of placing, changing, and understanding hypercommunication orders are simply so high to buyer and seller alike that bundling can cut the costs of exchange.

However, bundling can make price comparison among competing carriers a nightmare, especially for less-informed consumers. For example, some customers may not care about (or understand) the difference between an OSP (Online Service Provider such as AOL) and an ISP (Internet Service Provider such as Mindspring). OSPs offer local POP modem dial-up (narrowband) access to a subscriber-based content and e-mail network, with Internet access available (sometimes surrounded by OSP content frames). ISPs offer narrowband and high-speed Internet access, e-mail, data networking, use of ISP servers, and other services through a combination of local POPs for access and national or international backbone peering agreements for transport. [9]

However, it may be very difficult for customers (especially new Internet users) to compare the services between an ISP and an OSP (or to compare providers within each type) because bundling can force a comparison of apples to oranges. Most OSPs and ISPs have several plans which may include unlimited connection or access. That way, subscribers are not charged per e-mail message or by minutes of connection time. But bundles could include (or not include) web site space, 24 hour technical support, choice of billing plans, certain exclusions and limitations, access to CGI and JAVA script files, variations in e-mail features, and guaranteed or as-available connections. The difficulty is compounded when Internet, private data networking, and voice and enhanced telecommunications services may be combined as a single connection.

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[9] Remember from section 4.9.1 that Internet access and transport are actually two different service bundles. Strictly speaking, ISPs and OSPs offer transport level services that customers access via telephone lines or dedicated connections that are separately paid for. However, Internet transport is usually called Internet access.

The FCC and FPSC have prohibited ILECs from reselling *only* bundled services to competing ALECs in order to foster local telephone competition. During the days of AT&T, bundling was mandatory and often veiled in mystery unless specific legal language was enacted by the states. For example, all telephone sets were leased from AT&T's subsidiary, Western Electric. Access to local and long distance lines, telephone repair and replacement, outside wiring from CO (Central Office) to curb, and inside curb, residence, and business wiring was rolled into one bundle. Operator services such as directory assistance, billing credit (for unconnected, interrupted, or noise-filled calls), emergency (police, medical, fire, call interrupt) were bundled with local service. Per minute charges were levied on only certain services such as long-distance calls.

After the breakup of AT&T, the RBOCs (Regional Bell Operating Companies such as BellSouth) began to unbundle directory assistance, operator services, and inside wire maintenance, while using bundling to sell enhanced services and special calling plans. Bundling, rather than per channel pricing, is how most "non-pay" Cable TV channels are sold as well. Technological trends in carrier hardware and software have made un-bundling easier to implement for hypercommunications customers since new services are increasingly customizable. However, unbundling tends to make billing more complicated. Service bundling is still a popular convenience for many customers, allowing hypercommunications providers to combine sets of services together for special promotions or to induce trial, thus attracting new customers.

However, the ability to bundle services differently from competitors may also be used to make comparison shopping harder and it is arguable that bills are easier to understand. For that reason, bundling strategies of hypercommunications firms are sometimes accused of being anti-competitive. Now, some suppliers such as MCI, AT&T, and Bell Atlantic-GTE are positioned as single vendor solutions for the full range of hypercommunication services. It is possible to purchase wireline or wireless Internet, wireless phone service, local phone service, computer networking, paging, e-mail, voice mail, and long distance telephone services from a single firm that also installs and sells necessary CPE. Such single vendor bundling of sub-industry services into one billed service will be the mechanism that will enable hypercommunications convergence. Some critics allege that this will guarantee less competition in the long run, because the number of firms will be reduced through mergers and acquisitions, leaving only large international firms capable of providing every service. Consequently, it is charged, the remaining firms will obtain a high degree of market power.

6.2.2 Other Hypercommunication Units

The issue of bundling provides an excellent segue into other units used in hypercommunications to construct bundles. Almost all of these have been covered elsewhere, but Table 6-1 summarizes them, shows their location in the text, and summarizes their importance to the agribusiness demander of hypercommunications. Each item may be seen as a different trading unit of hypercommunications or as an ingredient to be used in creating a service bundle.

The most frequently used term of those shown is probably bandwidth. Bandwidth (or capacity) constrains the amount of data that can be sent over a particular link in a hypercommunications link. Closely related are data rate and throughput. The data rate is the single most important factor affecting the price of a communication link. Throughput, while it is related to the speed and capacity of the communications link, also depends on the CPE owned by the agribusiness. The three pertain to all kinds of digital communications from data transmissions to telephone calls and faxes. QOS refers to multiple dimensions of hypercommunications quality and reliability. SLAs are specific guarantees of QOS levels. These concepts are explained in detail in section 4.2.

While the first six units in Table 6-1 are used to create bundles that are sold for an accounting price, the next three items may be more important to determining the economic price.

The costs and benefits to an agribusiness of creating, using, and managing information within the organization are not directly priced in markets or measured on the balance sheet.

Table 6-1: Hypercommunication bundle ingredients (trading units).

Unit	Meaning and importance to agribusiness	Place in text
Bandwidth	Measure of capacity of communication connection; often what price is based on. Access and transport level capacity.	4.2.1
Data rate	Measure of speed of a communication link (DCE to DCE); price of digital connections may depend on data rate. Access and transport level speed.	4.2.1
Throughput	Measure of speed of communications (user to user), congestion and other negative network externalities show up here, as do problems with the agribusiness' CPE and local network.	4.2.1
QOS	Quality of service.	4.2.3
Bits and bytes	The bit is the smallest digital unit, a binary digit. Eight bits equal one byte. Bits are the chief units of digital communications; bytes are used to characterize the capacity of storage media.	3.2
ALEs	Access Line Equivalents. Number of simultaneous incoming or outgoing local (long-distance) telephone lines. Incoming need not equal outgoing.	4.7
SLAs	Service Level Agreements. Guarantees that particular QOS targets will be met.	4.2.3
Compressed time	Tendency for data processing speeds to move faster, causing decision periods to shorten and market conditions to change rapidly. Best prices and discounts require contractual lock-in for one to five years.	2.5.2.5
Data	Ore from which valuable business information can be created. Excess data are often unmanageable.	2.4.2
Information	Fundamental source of value in the "new economy". Can be a stock or flow, a resource or commodity, a perception of pattern, public good, uncertainty reducer, or organizational aid.	2.4
Service primitive	Techniques used to move data from one point to another. Can be connection-oriented or connection-less, reliable or unreliable, message-oriented, or byte stream.	3.3.2.4
OSI Level	Levels of network communications. Ranging from the physical level (wires and electrical energy that carries a signal) to the application level where communications occurs.	3.3.2.6

The last two items, the service primitive and the OSI level, underscore that the networked hypercommunications model of communications (and not the mass or interpersonal model) is at work[10]. The service primitive is merely a way of showing that hypercommunications takes many forms from e-mail and voice mail to interactive telephone or other real-time forms. The OSI model will help show the networking levels involved of a particular service.

However, many decision-makers have insufficient technological training to understand what their Internet options are, much less the full set of hypercommunication units. Often the firm providing hypercommunications services oversells or mismanages its capacity because of the many uncertainties involved in feedforward planning network management. Furthermore, suppliers may deliberately use nebulous units to achieve an information advantage. Therefore, it is especially important for agribusinesses to understand their unique hypercommunication needs.

6.3 The Hypercommunication Needs of Agribusinesses

Agribusinesses have a derived demand for hypercommunication services, based upon profit maximization, cost minimization, or other goals of the firm. An agribusiness manager needs to measure accounting and economic costs, benefits, risks, opportunities, and QOS uncertainties that accompany one hypercommunication choice over another. Unique communication needs for agribusinesses are where the costs, benefits, risks, and opportunities managers are interested in come from. For instance, the needs of a nursery with nine national locations (with both retail and wholesale customers) differ from those of a one-farm peanut operation or a multiple location cattle ranch.

Florida's climate, her geographic setting, her vast areas of arable land, and her people have given it a special place in American agriculture. The state has had many transitions, with agriculture contributing to the earliest ones and responding to the latest ones. This section gives a broad view of some of the unique hypercommunications needs of Florida's diverse agribusinesses. In doing so, a picture of hypercommunication's impact on agricultural input and output markets will also be painted since agribusiness hypercommunication needs depend on factors inside and outside the individual firm. Outside the firm, traditional agricultural sub-sectors and marketing channels as well as innovative new business activities of competitors influence a particular firm's needs. Additionally, the information economy combined with inexpensive global communications creates sources of new customers and new products. Inside the firm, the degrees of vertical and horizontal integration are especially important to hypercommunication needs.

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[10] Sections 2.2.2 and 2.2.3 explain this point in more detail.

Hypercommunication services are more than ordinary inputs and outputs. Information obtained by an agribusiness and exchanged within it can profoundly affect input and output markets for many goods and services, including those for agricultural products and services. Hence, the pricing and competitiveness of Florida's *hypercommunication market* has important effects on Florida's *agribusiness* input and output markets.

There are two chief ways hypercommunications improve agribusiness profits and growth. First, networked hypercommunications can cut the costs of supervision, control, and sales, while simultaneously allowing firms to operate on larger scales or wider scopes. Such results come from changes in the firm's front office (marketing and customer service) and back office (administration and manufacturing) technologies.

Second, information gathered through hypercommunications can change front or back office operations through technology spillovers. Technology spillovers occur when new knowledge is obtained directly and indirectly through hypercommunications, encouraging innovation throughout the firm. Innovation may be from product and systems development (such as a new invention or process that enables increased production while cutting costs or a new idea that frees resources allowing production of new items). Alternatively, the direct innovations may include the creation of information sales or other services. Hypercommunications can also create indirect innovation when new ideas help land, labor, capital, and management become better synchronized and more efficiently used.

This section covers five categories of interrelated agribusiness hypercommunication needs. Before covering those needs, the location and composition of Florida's agribusiness complex is summarized in 6.3.1. The developing agribusiness information economy is the first category of agribusiness hypercommunication needs, discussed in 6.3.2. Hypercommunication needs based on competitive strategies are considered in 6.3.3. Needs based on integration, channel width, and span-of-control are covered in 6.3.4. The fourth category of agribusiness hypercommunication needs (6.3.5) is based on the specific service, crop, or product sold by a particular agribusiness. Finally, needs based on an agribusiness' size or market area are covered in 6.3.6.

6.3.1 Location and Composition of Florida's Agribusiness Complex

Branson and Norvell define an agribusiness as "A firm involved in the production or distribution of agricultural commodities or agriculturally based products, or in the manufacturer and sale of farm inputs." [Branson and Norvell, 1983, p. 509] Agribusiness can be further broken into production agriculture and non-production agriculture to separate the production of raw commodities from the functions provided by the marketing chain.

The specific hypercommunication needs of agribusinesses depend on how broadly agribusiness is defined as well as where agribusiness and its trading partners are located. Communications needs depend on an agribusiness' location compared with its vendors and customers. Therefore, the hypercommunication needs of all agribusinesses (the agribusiness complex) are related to the communication needs of rural areas and production agriculture.

Based on these ideas, Figure 6-16 shows components of the agribusiness complex. In the figure, a distinction is drawn between production agribusinesses (areas C and D) and non-production agribusinesses (areas A and B). A second distinction is made between rural agribusinesses (areas B and C) and non-rural agribusinesses (areas A and D). Area E represents rural communities in general. The agribusiness complex includes areas A, B, C, and D.

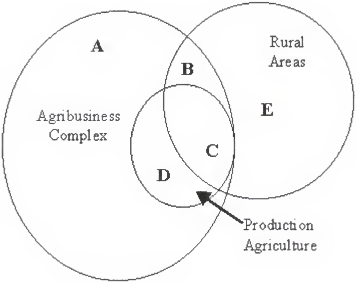

Figure 6-16: Locational and functional components of the agribusiness complex.

All three classifications have elastic definitions that affect the size of the agribusiness hypercommunications market considerably. The definition chosen for each classification alters the size of its circle in Figure 6-16. The combined definitions of production and non-production agribusiness determine the share of Florida's total economy made up by the agribusiness complex. The size of each circle can shrink or expand depending on that category's definition so that there may be differences in the relative importance of rural community infrastructures and non-production agribusinesses not shown by the scale of Figure 6-16.

The rural community circle is the first to consider. As Table 5-2 showed (in 5.2.1), the definition of rural varies, causing the rural communities circle (areas B, C, and E in Figure 6-16) to vary even more than the production agriculture definition.[11] Its size shows both the importance of agribusiness to rural hypercommunication infrastructure development and the importance of the rural markets to agribusiness hypercommunications.

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[11] Production agriculture includes areas C and D from Figure 6-16.

Consider the overlap between agribusiness and rural communities (areas B+C in Figure 6-16). If larger agribusinesses are the earliest adopters of high-tech hypercommunications services and technologies, then infrastructure inadequacies for an entire area might be improved as large agribusinesses demand new services first. Egan argues that business demand drives infrastructure development: "rapid development of an advanced communications infrastructure for rural America will depend on how easy it is for businesses to access the technology." [Egan 1996, p. 284] The size of the overlaps between non-production agribusiness and rural areas (area B) and production agribusiness and rural areas (area C in Figure 6-16) determines the importance of the rural hypercommunications market on agribusiness communication choices.

If hypercommunications can fade the traditional boundaries between rural and non-rural, then non-geographical spatial elements (such as market structure and technological limits) could become more important than geography. Since the information age makes the world smaller by improving access to previously inaccessible markets, agribusiness interaction with the world becomes more dependent on the geonomics[12] of the access level infrastructure and competition in rural markets. The rural circle is also important to agribusiness communications because of the fixity of assets since an orange grove cannot be moved to take advantage of a more competitive communications market.

The next circle, production agribusiness, can be three sizes as shown in Figure 6-17. First, production agribusiness may be defined narrowly to include only farms or ranches that produce field crops, vegetables, melons, field crops, and livestock. This conservative definition restricts the definition of production agriculture to traditional farming. However, some non-traditional operations such as aquaculture and horse farms may be included within this definition of production agriculture as well. Cash receipts for producers included by the first definition totaled $5.59 billion in 1999 [Florida Agricultural Statistics Service (FASS), 1999]

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[12] The term geonomic has been coined to refer to economic geography [Renner *et al.*, 1954, p. 4].

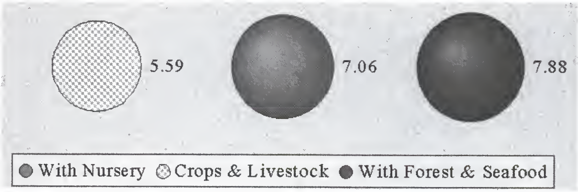

Figure 6-17: 1999 Cash receipts for three definitions of production agriculture (billions of dollars).

Second, production agribusiness may be defined to include all the products mentioned in the first definition along with foliage plants, floriculture, ornamental shrubs and trees, mushrooms, and sod. This expanded definition is important in Florida because the state produces the second most valuable greenhouse and nursery crop of all states in the nation [1997 Census of Agriculture, Ranking of States and Counties, NASS, 1999, Table 35]. The second definition also elevates the role of production agriculture in urban and suburban areas since greenhouses and nurseries are more easily fit into metropolitan areas than row fields and pastureland. Under this definition, Florida had 15,700 full-time farms with an average market value sold per operation of $172,000 in 1997 [NASS, Census of Agriculture, 2000]. Under the second definition, Florida's total cash receipts in 1999 total $7.06 billion [Florida Agricultural Statistics Service (FASS), 1999]

A third, even broader definition, includes the first two definitions, but adds farm woodland receipts and the dockside revenue gained by fishermen (landings). These producer groups increase cash receipts under this third definition to $7.88 billion in 1999 [DOACS *Locator*, 1997; Bureau of Seafood and Aquaculture Marketing, 1999; DOACS, *Florida*

Agricultural Facts, 1999, p. 71]. The third definition seems appropriate when the total land in production is concerned. The 1997 Census of Agriculture reported that Florida had 10.5 million acres of farmland (some thirty percent of the state's total land area). In 1997, almost 35% of all Florida farmland was cropland, while 20% was woodland and 39% was pastureland [USDA NASS, 1997 Census of Agriculture, 2000].

All firms in production agriculture are agribusinesses. Based on the vast amount of land area in production, it might appear as though most production agriculture operations are in rural Florida (area C of Figure 6-16). Surprisingly, however, over 76% of Florida's production agriculture workers are located in metropolitan areas [USDA ERS, "Florida Fact Sheet", 2000]. In Florida, most urban and suburban production agriculture operations are nursery and greenhouse operations but a scattering of farms that are located in areas where agriculture has been largely replaced by housing are also included.

Production firms typically cannot change their locations at will. This asset fixity is important when considering the market for agribusiness hypercommunications in Florida. Figure 6-18 shows general locations of citrus, vegetable, crops, livestock, and natural agriculture (forestry and fishery) operations [USDA NASS-FASS, ***Florida Agriculture Facts***, 1999, p. I].

However, while the map in Figure 6-18 does not suggest it, many of Florida's most productive production agribusinesses are located in counties with major metropolitan areas or have trading that is geographically concentrated in some other way. This concentration occurs not just within Florida, but within the nation and the world. The location of producers near a metro area may increase their communication options, suggesting perhaps that agribusiness is not as dependent on marginal rural infrastructures as some have suggested. However, while proximity to an urban area may mean that an agribusiness' chances for competitive access to hypercommunications are improved, it does not guarantee a competitive market as the discussion of technical, political, and regulatory boundaries in 6.1 testifies.

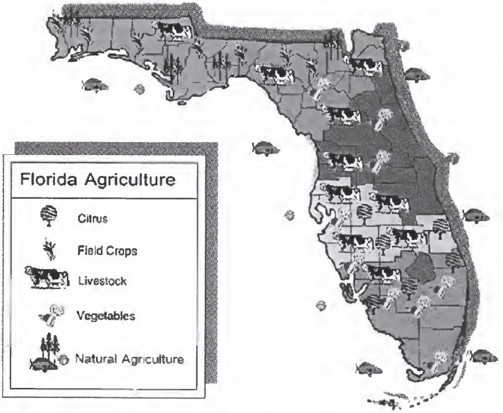

Figure 6-18: Florida agriculture specialization by region.

The concentration of producer revenue within Florida depends on the commodity as Table 6-2 and Table 6-3 show. Table 6-2 shows the market value of all agricultural crops (on the left side) and the value of nursery and greenhouse sales (on the right side). Each part of the table shows the 1997 ranking of the top Florida counties among all 3,100 counties in the United States. A few Florida counties represent large fractions of total production value as Table 6-2 shows.

Eight Florida counties are ranked among the top 100 counties nationally in the market value of agricultural products sold in 1997. Producers in these eight counties received forty nine percent of total cash receipts for the entire state. Four counties of the eight, (Dade, Palm Beach, Hillsborough, and Orange Counties) are the state's first, third, fourth, and sixth most populous counties (in that order). Florida ranked ninth nationally in the value of cash receipts.

Table 6-2: Florida counties among the top 100 ranking counties nationally (for value of agricultural products or for value of nursery and greenhouse crops)

Market value of agricultural products sold, 1997			Value of nursery and greenhouse crops, cut Christmas trees harvested, mushrooms, and sod sold, 1997		
County	Rank	$ (millions)	County	Rank	$ (millions)
Palm Beach	11	872.9	Dade	2	242.7
Dade	39	416.5	Palm Beach	7	174.6
Hillsborough	57	332.7	Orange	8	172.1
Hendry	58	323.4	Lake	15	118.8
Collier	77	276.9	Volusia	17	111.5
Polk	85	253.5	Hillsborough	27	71.6
Orange	91	247.8	Gadsden	33	53.5
Manatee	97	239.6	Manatee	41	45.2
Ranked counties 49%		*2,963.3*	Broward	50	37.5
Florida Total	9	6,004.6	Lee	53	36
			Collier	54	36
			Osceola	75	27
			Polk	75	27
			Highlands	100	21.2
			Ranked counties 81%		*1,174.7*
			Florida Total	2	1,450.0

Source: USDA NASS, *1997 Census of Agriculture*, Ranking of States and Counties, Table 23 and Table 35.

On the right side of Table 6-2, fourteen Florida counties were in the top 100 counties nationally in the value of nursery and greenhouse crops, Christmas trees, mushrooms, and sod. Five (Dade, Broward, Palm Beach, Hillsborough, and Orange) of the state's six most populous counties appear among the fourteen. Only Highlands County is not part of a Metropolitan Statistical Area (MSA). Together, the fourteen counties represent eighty-one percent of total nursery and greenhouse cash receipts. Florida ranked second nationally, behind California.

In Table 6-3, production is even more concentrated among ranked counties. The table shows the value of vegetables, melons, and sweet corn (on the left side) and the market value of fruits, nuts, and berries (on the right side). Florida is ranked second nationally, behind California, in both categories.

Table 6-3 Florida counties among the top 100 ranking counties nationally (for value of vegetables or for value of fruits)

Market value of vegetables, melons, and sweet corn sold, 1997			Market value of fruits, nuts, and berries, 1997		
County	Rank	$ (millions)	County	Rank	$ (millions)
Palm Beach	6	248.8	Polk	17	175.1
Collier	10	169.2	Hendry	18	165.9
Dade	13	129.2	Desoto	19	143.3
Manatee	14	120.4	St. Lucie	21	141.9
Orange	23	60.3	Highlands	22	139.3
Hendry	25	57	Hillsborough	24	135.2
Hillsborough	26	56	Hardee	30	101.1
Lee	28	54.3	Indian River	34	84.2
Gadsden	46	29	Martin	39	69.1
Martin	54	20.5	Collier	46	55.7
Suwannee	69	16.7	Manatee	52	44.1
Alachua	86	13	Charlotte	65	30.5
St. Lucie	98	11	Osceola	66	29.8
Ranked counties 91%		*985.4*	Lake	75	23.8
Florida Total	2	1,083.9	Okeechobee	85	20.2
			Dade	87	19.5
			Lee	89	18.9
			Glades	90	18.0
			Pasco	99	14.8
			Ranked counties 96%		*1,432.4*
			Florida Total	2	1,493.5

Source: USDA NASS, *1997 Census of Agriculture*, Ranking of States and Counties, Table 33 and Table 34.

Vegetable, melon, and sweet corn producers in the thirteen ranked counties were responsible for ninety-one percent of Florida's total cash receipts for those crops. Again, four of the state's six most populous counties are on the list. Two counties (Hendry and Suwannee) are not located in MSAs. The market value of fruits, nuts, and berries (on the right) captures mainly the influence of the citrus crop. Nineteen Florida counties are ranked in the top one hundred nationally in this category. Producers in those ranked counties make up over 96% of fruit, nut, and berry cash receipts. This category includes only two of the six most populous counties, and only Hillsborough makes a large contribution. Seven counties (Hendry, Desoto, Highlands, Hardee, Indian River, Okeechobee, and Glades) are not located in MSAs.

Tables 6-2 and 6-3 suggest four important points about hypercommunications and production agribusinesses. First, while county-level data cannot distinguish between the subtleties of urban and rural areas (as 5.2.1 mentions), county-level data can be used to suggest that many production agribusinesses are located near a metropolitan area. However, although many of the most productive agricultural parts of Florida are within the local calling area of a metropolitan area, that does not guarantee they will have high-speed hypercommunications access. Nonetheless, producers in MSAs (an especially those in the most populous counties) are in a better position than those in other parts of the state to receive high-speed wireless access. Depending on local boundaries, these MSA producers are also more likely to have several choices for wireline access now or in the near future.

Second, the ranking data suggest that production agriculture (in general) and the citrus industry (in particular) are less concentrated in MSAs. Thus, if high-speed access and competition in hypercommunications are related to county density, some sectors of production agriculture will fare worse than other sectors in the next few years. A third point concerns the difference between revenues and the number of operations. Tables 6-2 and 6-3 use rankings based on revenues, not farm numbers. Rankings based on countywide revenues do not tell anything about the total number of operations.

Fourth, the tables suggest possible differences in access among producers of a particular crop based on location. A nursery in Broward County probably has (and will continue to have) better access and more hypercommunications choices than will a Gadsden County or Highlands County nursery. To the extent that hypercommunications give producers a business advantage, that advantage may come only to producers who are located in advantageous locations to begin with. It is important to note that advantageous locations may be based on factors such as transportation routes and distance to market that are positively correlated with hypercommunications advantage.

The rural circle and the production agriculture circle shown in Figure 6-18 have now been covered. The analysis above suggests that the rural circle may represent a somewhat smaller part of production agribusiness than would be expected in other states. However, many agribusinesses cannot be classified as production agriculture. The third circle, non-production agribusinesses, makes up four basic areas: farm input suppliers, processors and marketing firms, wholesale, and retail operations.

Again, there is a question of how broad the definition should be. According to Florida's DOACS, the agribusiness complex contributes \$20 billion in direct farm-related economic impact on the state and \$55 billion in direct and indirect value added from the farm gate to the supermarket [DOACS, *Florida Agricultural Facts*, 1999, p. 1]. Forest and forest products contribute an additional \$8 billion to the state's economy, while the seafood industry adds \$1.4 billion to the economy [Jacobsen and Vericker, 1998; Bureau of Seafood and Aquaculture Marketing, 1998]. Thus (as shown in Figure 6-19), depending on the definition of the production that underlies their efforts, non-production agribusinesses add between \$33 billion and \$84.4 billion to Florida's gross state product. With Florida's gross state product estimated at \$400 billion, the agribusiness complex contributes from eight to twenty-one percent of that amount.

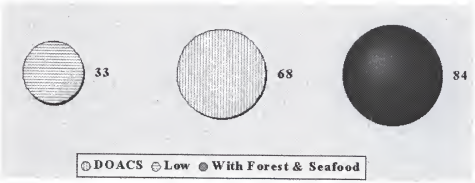

Figure 6-19: Three estimates of the total economic impact of Florida non-production agribusinesses (billions of dollars).

Most non-production agribusiness employment is in non-rural areas. According to the ERS and other agencies, 14.2 percent of total metro area employment was in farm and farm-related jobs while 22.1 percent of total non-metro employment was in farm and farm related jobs in Florida during 1996. When extrapolated onto 1998 total employment, this translates into over 1,100,000 employees of metro agribusinesses and almost 99,000 employees of non-metro agribusinesses in 1998 [USDA ERS, Florida Fact Sheet, 2000]. When employment in forest products and the seafood industry are added in, the total climbs to the 1,479,722 employees as shown in Figure 6-20 [Jacobsen and Vericker, 1998; DOACS, *Florida Agricultural Facts*, 1999, p. 75; DOACS, "State of Florida Facts", 2000].

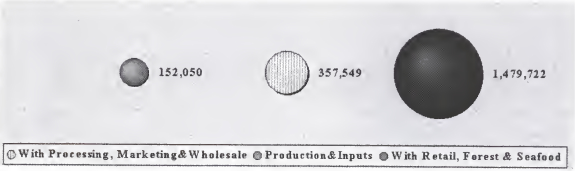

Figure 6-20: Total employment of Florida's agribusiness complex varies by definition.

The broadest definition of an agribusiness in Figures 6-19 and 6-20 would include the communication needs of retail outlets as wide ranging as grocery stores, restaurants, and furniture showrooms. However, the narrowest definition might exclude important parts of the agribusiness complex that are responsible for adding the most value to food and fiber producers output. Clearly, the more people employed by the agribusiness complex, the greater the need for hypercommunications and the greater the size of the agribusiness hypercommunications market.

However, there is no definitive answer to the size of the agribusiness complex. The relative sizes of production compared to non-production and the overall size of the agribusiness complex give different pictures of the extent of the hypercommunications market. Many hypercommunication needs do not depend on the size of the agribusiness hypercommunications market but on the unique characteristics of agriculture and specific characteristics of individual firms. Before considering some of the more specific needs based on competitiveness, vertical-horizontal integration, agribusiness type, or size of agribusiness, the next sub-section considers the needs of the agribusiness sector as a whole.

6.3.2 Unique Characteristics of Agriculture and Agribusiness Hypercommunication Needs

It is often said that agriculture is a unique industry. While that is true, in many ways, the discussion in Chapter 2 of the three foundations of the information economy (communication, technology, and information) applies to agribusiness just as it does to other industries. Some have argued that extractive industries such as agriculture and mining are somehow not part of the new "weightless" economy [Rawlins, 1992]. In spite of those arguments, many agree that over the past decade agriculture has evolved into "an information-intensive food production system" [Saxowsky and Duncan, 1998, p.5].

Taylor and Fairchild explain how IT will transform agribusinesses:

> Perhaps the most profound impact on trade and competition will be created by changes in information technology. Supply chains evolve to minimize the cost of information flow and its management, thus transactions costs along the supply chain have been altered by access to real-time information at very low cost. Examples include the decline of traditional wholesale distribution channels and the increase in vertical and horizontal strategic alliances in the fresh fruit and vegetable sub-sector. [Taylor and Fairchild, 2000, p. 2]

Hypercommunications provide the raw data from which agribusinesses glean information they need to learn about and respond to customer needs, buy and sell inputs and outputs, perform business intelligence, and manage multiple locations. The objective of the information intensive agribusiness is to gain an economic advantage in an increasingly competitive international market by minimizing the cost of bandwidth (capacity) while maximizing information literacy and improving the efficiency of information handling. The intended result is asymmetric information[13] or an informational advantage that can be used to raise profits, increase sales, find new products, enter new markets, and lower costs.

Given the importance of the information economy to agribusiness and the importance of hypercommunications access and transport to information acquisition, many unique characteristics of agriculture create specific hypercommunication needs. Table 6-4 lists eighteen unique characteristics of agriculture, describes each one and related agribusiness hypercommunication needs.

Not every item in Table 6-4 is unique to agriculture. Other industries have instability, asset fixity, and environmental concerns, and share many of the economic characteristics mentioned with agriculture. The true uniqueness of agriculture (and the source of many unique agribusiness communication needs comes) from the fact that the *combination* of characteristics in Table 6-4 and *interaction* among them are specific to agriculture alone.

The first unique characteristic to agriculture is the uncertainty biology brings to production. Tweeten describes this as the "unpredictable and uncontrollable influence of weather, insects and other pests, diseases" and the resulting impact they place on producers and non-production agribusinesses alike [Tweeten, 1989, p.20]. Having better information can prevent or reduce risks, while improve timing and efficiency. Hypercommunication is especially important because it provides the pipeline information flows over to reach farms and ranches that require an increasing amount for precision agriculture or other high-tech information-based production needs.

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[13] See 2.4.6 for a discussion of asymmetric information along with the broader discussion of the economics of information in 2.4

Table 6-4: Unique characteristics of agriculture result in agribusiness hypercommunication needs.

Characteristic	Description	Hypercommunication needs
1. Biological production uncertainty	Unpredictable, uncontrollable influence of weather, insects, and diseases.	Many. More information can prevent or reduce risk.
2. Inelastic SR price elasticity of demand	Food maintains life. Food security is important to national security.	Disaster recovery, food aid, international markets.
3. Inelastic SR price elasticity of supply	Once crops or trees are planted or animals are bought, suppliers cannot adjust to price changes.	Many. Real-time information allows better producer reaction.
4. Low income elasticities of demand	Consumer budget share for food is low, falls as income rises.	Many. Better service, niche and direct marketing, customization.
5. Producers may face highly price elastic demand	Producers have no market power. They depend on volatile spot, forward, futures, and options markets.	Many. Real-time information helps tailor strategy to price.
6. Dependency on global markets	Exports are important due to foreign competition and worldwide commodity markets.	Low communications costs reduce international barriers.
7. Fixity of assets	Tractors, land, agricultural equipment may be little use for anything other than specific crops.	Few. Assets for sale may be more liquid.
8. Legislative and public relations	Governments target policies to agriculture; importance of family farm, image of agriculture	Some. Agriculture's story is both cheaper and harder to get across.
9. Environmental concerns	Farming practices influence the natural environment, many are under attack.	Many. Improved industry practices, better education.
10. Food safety and health	Legal and ethical burden to provide safe and healthful food throughout distribution chain. Food is the source of human nutrition; importance of organic products	Many such as problem response and prevention, interactive education.
11. Bio-technology	World food crisis created need to improve productivity, nutrition, and safety. Opponents cry "frankenfoods".	As in #10, but add the transgenic firm, new legal rules.
12. Seasonality of demand, supply	Importance of timing in marketing chain at producer, wholesale, and retail levels.	Information can match demand seasonality with supply seasonality.
13. Storability, perishability	Certain products spoil quickly, require storage or special shipping and handling.	Tracking, automated ordering, shipping.
14. Importance of cooperative action	Producers are too small to vertically integrate unless they cooperate. Little incentive exists outside of group action to advertise and market commodities.	Varies based on whether management is centralized or vested in members.
15. Farm and other labor	Shortages, controversy over illegal immigrants and housing. SOHO, mobility, cybercommuting.	Important to full-time or mobile sales workers.
16. Land and land tenure	Social, economic issues regarding farm tenancy, urban encroachment.	Role of infrastructure location on returns.
17. Influence on rural areas	Some areas are economically dependent on farming.	Varies by location.
18. Cycles and instability	Animal, orchard, commodity cycles, and instability of returns increase risk, lower speed of adjustment.	Information about risk and instability.

Source: some characteristics are based on Tweeten, 1989, pp. 1-31.

Biological uncertainty brings specialized hypercommunication needs to non-production agribusiness also. Having better information about weather and other uncertainties faced by producers that can create potential supply shocks helps marketing firms plan evasive action. Such evasive actions include increasing stocks, increasing storage capacity, searching for alternative suppliers, and changing recipes or formulas. Information about competitors' actions and technology transfers[14] also helps non-production agribusinesses weather supply shocks due to biological uncertainty, even helping with invention of new products and processes that improve an entire operation or product line.

A second unique characteristic is the inelastic short-run price elasticity of demand of food at the industry level and for many individual agricultural products. The main reason for the short-run demand price inelasticity is that food products are essential to human and animal life [Tweeten, 1989]. In emergency conditions such as hurricanes or other disasters, restoring communications to agribusiness to ensure a steady food supply can prevent famine and public unrest. For this reason Florida disaster preparedness instructions for communications restoration rank non-production agribusinesses (retailers, wholesalers, and middlemen) behind only law enforcement and health care as an essential service. Larger agribusinesses and retail operations need to have robust, redundant communication systems because of the importance of food to society.

Food security is important to national security. Thus, international agribusinesses, food aid, and food policy require effective and efficient transportation and communications infrastructures. IT and hypercommunications can allow cheaper and more effective timely international communications than ever before. However, foreign infrastructure and the protection of national PTT (Post, Telephone, and Telegraph) monopolies can hamper the ability of agribusiness and NGOs to communicate cheaply.[15]

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[14] The technology-information linkage (2.3.7) and technological spillovers from research and organizational improvement (2.3.5) are ways technology is transferred. Through hypercommunications, firms seeking information about a small problem may end up using the information gathered to innovate and change the entire organization.

Another unique characteristic of agriculture is price inelastic short-run supply. Once crops or trees are planted or breeding stock is purchased, suppliers cannot adjust quickly to changes in price. For example, once a field crop has been planted and starts to grow biological processes take over, and farmers cannot change short-run supply response[16] to price as well as producers in many other industries can. The impact hypercommunications can play in mitigating negative effects of this characteristic is major. For example, localized real-time information about planting intentions could allow producers to form more informed expectations, possibly helping to reduce the chronic oversupply that plagues U.S. agriculture.

A fourth unique characteristic of most agricultural products is that income elasticities of demand are low [Tweeten, 1989]. As incomes rise, much of the increase is spent on goods and services not related to the agribusiness sector. Therefore, growth in demand for food products must come from overseas markets or from population growth rather from better economic conditions.

However, new methods of marketing and positioning agricultural goods and services can counteract this. Direct marketing techniques, agri-tourism, eco-tourism, recreational tourism, and niche product positioning can be used to keep some production agribusinesses in farming by diversifying operations and improving bottom lines [USDA AMS, 2000]. These techniques require a high dependence on hypercommunications especially because such agribusinesses must have the ability and capacity to handle more communication directly with consumers than they are accustomed to. Non-production agribusinesses may have to vertically integrate (and even establish retail arms) as IT alters the supply chain. Better communications are at the heart of both strategies. In both cases, better customer service, customized products, and real-time information are needed to appeal to and serve high-income customer demand. Such a strategy can help counteract both low income elasticities of demand and the next characteristic, price taking.

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[15] A recent example is given by Belize's national PTT monopoly, which controls all wireline Internet access into and out of the country. Free website-based voice over IP services such as www.dialpad.com are blocked by the government so that no international voice communication other than expensive, monopoly-provided telephone calls can occur.

[16] It is true that if farmers expect a high price at harvest they can add inputs to increase yields. It is also true that if an extremely low price (below average variable cost) is expected, it may be cheaper to abandon a planted crop. However, if a field is suited for both wheat and corn but the farmer plants wheat, he cannot rip out the wheat crop and replace it with corn, especially in areas with one growing season.

A fifth characteristic of agriculture is that individual producers face an extremely price elastic demand. Producers have little market power so they are dependent on prices that are set in spot, futures, forward, and options markets. By altering the marketing strategies of the agribusiness (by offering custom services and personalized products aimed at high-income groups as described above), a producer may become a monopolistic competitor with somewhat more control over price. Additionally, even for commodity producers and marketing firms that depend on open market pricing, better information can help the timing of buying, selling, storage, and other decisions to lessen the effect of price instability. The Internet has created a revolutionary increase in the availability of real-time information about markets and prices along with new markets. Transaction costs have plummeted, while the amount of available information has grown faster than the costs of access and transport have fallen. However, it can be hard to evaluate the quality of large quantities of information.

On a related note, agriculture's next unique characteristic is its "high dependency on precarious foreign markets" [Tweeten, 1989, p. 21]. The DOACS reports that for U.S. fiscal 1997-98, almost $1.1 billion dollars worth (16.3% of cash receipts) of production-level crops were exported from Florida. In addition to new foreign markets for citrus juices, increased competition with Mexico in tomatoes, squash, snap beans, cucumbers, bell peppers, and other vegetables shows Florida producers and processors that the domestic market is really a world market. However, Florida's strategic position near Latin American growing markets and the promise of improved trade with the Caribbean and Africa should see its rank climb from the 17th leading U.S. agriculture export state. Not to be ignored is the importance of foreign markets as a source of production inputs and ingredients for non-production agribusinesses.

Several hypercommunication needs stem from the importance of global markets on agribusiness. Most importantly, lower costs of communications with overseas (especially via the Internet) allow even small agribusinesses to seek new buyers or vendors anywhere in the world. While the importance of global markets varies by crop, hypercommunications also allow agribusinesses to be well informed about international markets, import and export regulations, and gives them closer contact with foreign agents or salespeople. While inexpensive hypercommunications increases international communications, this is one area where middlemen (such as export brokers and importers) could see their roles grow due to the red tape involved in international trade.

The seventh unique characteristic discussed in Table 6-4 is fixity of assets. Much of the capital equipment used in agriculture may be specific to agriculture only or even to a specific crop or animal. While many agribusinesses are leaving agriculture or moving operations as urbanization swallows up vast tracts of arable land in Florida, some land is so remote or otherwise unsuitable for development that it too must remain in farming or become idle.

While hypercommunications does not alter the physical reality of asset fixity or reverse urbanization, two communication needs relate to this characteristic. First, assets that have to be sold may be more liquid since the Internet can increase the seller's audience size substantially, broadening the extent of the market. Second, to the extent that an improved hypercommunications infrastructure can help agribusinesses increase returns on land, it is possible that more land will stay in agriculture instead of being converted to urban uses.

Another unique characteristic of agriculture is the importance of lobbying, government relations, and public relations. Many federal and state policies are specially targeted to agriculture so that both production and non-production agribusinesses have special communication needs based on their membership in a common political network with similar interests. The importance of the family farm to U.S. farm policy is one example of a message that goes across commodity lines. In many other cases, segments of agriculture work at cross-purposes. Agriculture's story is cheaper to get across over the Internet due to low per unit costs of web pages and legislative alert e-mails. However, agriculture's story is also harder to get across through the clutter of increased message traffic.

Producer associations, trade groups, and farm organizations are using the Internet (along with Internet site design and promotion suggestions such as those given in 4.9.3 through 4.9.5) to defend, explain, and educate the public about Florida agriculture. Organizing letter campaigns or other efforts among members of a human network connected by a common communications network with a choice of message types (like the Internet) is cheap, effective, and simple.

The ninth unique characteristic is agriculture's effect on the natural environment. While other industries affect the environment, production agribusiness is unique because it occupies more land area than any other industry. Farming practices such as agrochemical use, monocropping, soil conservation, wetlands reclamation, land use, water use, and others influence the overall natural environment. In Florida, many of these practices are under attack, such as the controversy regarding the alleged contamination of the Everglades by sugar operations and dairies. Just as with the public relations-government characteristic just mentioned, hypercommunications (especially the Internet) allows agriculture to get its message out quickly and cheaply. It is easier than ever for agribusinesses to explain their positions and educate the public through group or individual action. The Internet creates new venues of debate and opens (through e-mail and other technologies) new methods of communication. Also important is environmental education of farmers themselves, made cheaper for extension and other interest groups.

Another unique characteristic of agriculture is the importance of food safety and healthfulness. In reality, this characteristic covers several areas. First, agribusinesses have a legal and ethical responsibility to provide safe food products throughout the distribution chain. Second, since food is how human nutrition is satisfied, information about the nutritional content, best ways to prepare, and information about disease fighting properties of food are important to the public and news media alike. A third area important to non-production agribusinesses especially is the burgeoning nutraceutical market.

These areas give birth to several hypercommunications needs. First, the ability for an agribusiness to communicate the details of a food recall swiftly and accurately to retailers or other distributors is important. Since communication is a two-way process, handlers or other manufacturers must be able to answer questions about a recall or food safety scare from other agribusinesses, the news media, and the public in as uniform and accurate a manner possible. Interactive web sites, e-mail response teams, emergency communications policies, real-time inventory location networks, and telephone hotlines are some examples of specific tactics that might be necessary. Now, such techniques do not require a large staff or a big budget to implement.

In addition to the prevention of and response to safety emergencies, consumers are increasingly concerned with the quality of the food they eat. This concern can include nutritional labeling, fat content, country of origin, humane animal production, organic production, preservative and additive content, and the disease-fighting or health risks of particular foods or additives. Therefore, in addition to providing food, agribusinesses provide information about food. Indeed, such information may be more than general information or recipes; it may have to accompany product through the distribution chain. This task may eventually require an extranet for data and inter-channel voice communications among (and within) each level of the marketing chain.

Non-production (and some production) agribusinesses need to be equipped to handle questions from the public ranging from recipes to nutritional information. Customers may require assurance that organic foods really are organic beyond simple labeling. Information about general handling and the specific history of a particular purchased item are especially important to kosher, organic, and humane-animal production shoppers. Increases in customer interest could result in communications volume that may require an increase in communications capacity and staff. Internet and call center technologies provide inexpensive methods to handle such needs provided the advice given in Chapter 4 is followed.

Another issue has recently gained greater importance to form the eleventh unique characteristic of agriculture. This is the issue of biotechnology or the use of genetically modified or biologically altered foods within the food chain. The world food crisis created the need to improve agricultural productivity, increase nutrition per unit, and improve food safety. One way agricultural scientists have responded has been by genetically altering crops and animals to make them grow larger faster while using fewer resources. However, these moves have created changes in distribution chains (the so-called transgenic firm, Baarda, 1999) as well as cries of "frankenfood" from certain groups who claim that genetically altered foods are both unethical and dangerous.

Again, the communication needs created by biotechnology tend to be based on tracking information about a particular batch or lot from the farm gate to table. Biotechnology increases the importance of such information to agribusinesses because biotech foods are patented and cannot be bred, copied, or otherwise handled outside of vertical and horizontal rights without risking legal penalties. Thus, in addition to public relations communication needs and the need to track and label biotech foods to satisfy consumer concerns, agribusinesses must carefully track movement of these products to avoid lawsuits. The need to track food and information about specific lots, batches, and shipments of food as it moves through the distribution process is simplified considerably by using private data networking. That means an Intranet or VPN within a firm, an Extranet or web-based VPN among firms, and a strategy for communicating directly with wholesale and retail buyers that may include call center technology, e-mail, and a web page.

A twelfth unique characteristic of agriculture is the seasonality of demand and supply. Specific hypercommunication needs are necessary because of the importance of market timing at the wholesale, producer, handler, and retail levels. Seasonality is important to producers because the time of planting and harvest are chosen to fetch the best return. For non-production firms, the task of equating demand seasonality with the seasonality of supply is a difficult one.

An example should clarify the difference between demand seasonality and the seasonality of supply. Ice cream exhibits demand seasonality based on how hot temperatures are. Cows produce milk throughout the year, so there is no significant seasonality of supply.[17] Snap beans are harvested in Florida from January through March while Florida strawberries are in season from February 1 to the end of April. Both strawberries and snap beans produced in Florida exhibit seasonality of supply. It is far easier for dairy producers to produce ice cream according to changes in demand related to the weather than it is for strawberry or snap bean producers to change production seasons or space production evenly through the year.

Handlers and other marketing firms must decide whether it is more profitable to store production and release it over time at a constant level or to market crops as they are harvested. For some crops such as fresh snap beans and fresh strawberries, the agribusiness complex aims at specific market windows. For example, Florida produces 100% of the domestic snap bean supply during the January-March window.

Some of the communication needs resulting from seasonality relate to many that have already been covered. Seasonality makes it clear that communication needs vary by level of distribution and by crop. Since there are a variety of marketing strategies, there are a variety of communication needs. Generally, it can be argued that better and more timely information helps agribusinesses execute strategies better. This is especially true when hypercommunications allows more information to be gathered faster and cheaper than using standard telecommunications.[18] The Internet and other forms of hypercommunications are especially helpful to retailers who are regularly looking for sources of fruits and vegetables.

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[17] Of course, there are seasonal differences in milk production because cattle produce more milk in some months than others. However, they are able to give milk throughout the year.

The next set of unique characteristics handling, storability, and perishability are related to seasonality. The fact that many kinds of foods (including vegetables, meats, and fruits, and dairy products) require special handling such as refrigeration or packaging is also closely related to food safety and healthfulness. In addition, it is often desirable to store products over time to plan for seasonal changes in retail demand or to ensure that they are available to agribusinesses that use raw or processed ingredients to produce finished foods. Perishability crops (such as certain vegetables and fruits) spoil quickly so the time it takes them to travel from farm to table must be kept as short as possible. Since Florida produces the second most valuable vegetable crop in the country, handling, storability, and perishability are important issues.

Several communication needs result from storability, handling, and perishability. The most obvious is the importance of logistics. Improvements in logistics (the timing, scheduling, and delivering of goods) have come from information technology and from hypercommunication technologies. Through a combination of Intranets, GIS positioning transmitters in trucks, and other inexpensive wireless tracking systems such as the Ardis network, it is possible to pinpoint the location of any shipment with great precision. A value-added service that can be offered is the ability of customers to track their orders using the agribusiness logistics system (often furnished by the merchandise carrier) via a web site or extranet. Information technology and hypercommunications accurately track handling and storage as well. Retailers are able to move produce (and other goods) from distribution centers to stores as needed, using real-time, automated systems that use private data networks and powerful inventory applications to automate ordering and shipping. However, such systems are only as good as the people who run them and are too costly at present for smaller firms to afford.

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[18] Hypercommunication and telecommunication are compared in Table 2-1 in 2.2.4.

The fourteenth unique characteristic of agriculture (the importance of co-operative action) stems directly from the fifth characteristic (no market power for individual producers). Since individual producers have no market power, there is an incentive for group action to vertically integrate, lobby, and establish and fund advertising and marketing programs. Since co-ops are member owned and operated, they may require particularly good hypercommunications. The kind of communications needed depends on whether the co-op has a strong centralized management or operates with strong member control and choice [Branson and Norvell, 1983, pp. 258-265].

Co-ops may require inexpensive communication links from handling or processing locations to producer-owners. In addition to using e-mail extensively to inform members, co-ops offer subscription web-based access to account and other co-op information for members. Many commodity advertising and promotional efforts require web-based marketing as well, so that individual producers may obtain some of the benefits of being on the Internet without each getting a separate website.

A fifteenth characteristic where agriculture is unique compared with other industries is the farm labor market. It is widely known that there are two farm labor markets, the market for full-time production workers, and the market for part-time, seasonal workers to help with the harvest. The nature of harvesting crops is such that many production workers are part-time. The shortage of farm workers and controversy over illegal immigration and worker housing conditions combine to create a labor market that is unstable and sometimes an embarrassment to the agricultural sector.

While many industries find that the Internet helps them find employees from all over the country, the part time farm labor market is probably an exception since most migrant workers lack information technology skills and network access. However, better communications helps labor contractors search for workers cheaply over a wide area. IT and hypercommunications are important for firms such as Florida Agricultural Services who can take care of all hiring, paperwork, and wages for production workers.

The market for full-time employees in production and non-production agribusiness is increasingly using the Internet for successful nationwide recruiting. As with the rest of the economy, agribusiness communication networks must be flexible enough to handle cybercommuting and SOHO users. As was mentioned in Chapter 4, Internet and Intranet VPN solutions along with the ability to place and receive telephone calls at home offices as though in the office are growing more important. New technologies make these options affordable even for smaller firms. The ability to communicate while mobile can be important to busy producers, agribusiness sales staff, and other personnel. Figure 4-29 in 4.4 showed the enormous variety of mobility and data rates available for second and third generation wireless services.

Land and land tenure issues are another unique characteristic of agriculture. There are many social and economic issues related to farm tenancy and urban encroachment on production agriculture. The communications impact here is uncertain also, but there are a few issues related to hypercommunications that arise. One issue (already mentioned under asset fixity) concerns the extent to which land becomes more valuable and more productive based upon its proximity to high-speed hypercommunications infrastructure or its location inside hypercommunications market boundaries (6.1). For farmers who are seeking additional land or who wish to find tenants, the Internet is becoming increasingly important. While real estate is not sold over the web, detailed descriptions and illustrations of property help principals and agents alike to select parcels worthy of further consideration.

The seventeenth unique characteristic of agriculture, the influence of the agribusiness economy on rural areas, has already been discussed. In Florida, some small communities (and even entire counties) are classified as agriculture-dependent. That means that the farm economy and non-production agribusinesses (together with economic multipliers) may represent the bulk of the economy in a particular area. Chapter 5 regarding rural hypercommunications policy (along with specific infrastructure and service material in Chapter 4) discuss problems of rural areas in detail.

The last unique characteristic of agriculture concerns cycles and instability. While already encompassed by other characteristics, the cycles and instability inherent in agriculture bear separate mention because they highlight several hypercommunication needs. Animal, orchard, crop and commodity life cycles are a part of agriculture that were well known before computers were invented or the Internet was created. One communications need is the need for practical information from purposeful communication. Hypercommunications can help agribusinesses reduce risk by serving as the direct, real-time link to the trading floor where risk is transferred. Information gained through hypercommunications and then crunched by computer can help agribusinesses tell how important commodity cycles are to their business. Some of the instability present in agriculture can be smoothed simply with better information. Better communications and information may reveal that some agricultural cycles may be in the mind of the technical analyst rather than in the reality of the market.

Another communication need is to ask, instead of how to do my job right, what is the right job to do?, as Peter Drucker does. For example, it can be easy when thinking about the time compression that information technology has ushered in to forget that citrus trees are classified as unbearing "by popular custom" for the first four years after they are planted [Jackson, 1991, p. 137]. It is easy to think that regardless of how quickly the grower can communicate with the outside world, the orchard cycle creates a four-year lag in how quickly he can adjust to market signals.

But instead of deciding to run a citrus operation in indifference to the information age, many growers understand the edge that hypercommunications can give them in spite of seemingly unbendable natural laws. Communication with the outside world, perhaps while "wasting time and being inefficient" is "the way to discovery" according to Kevin Kelly [Kelly, 1997, p. 14]. As technological changes occur, information technology will probably continue to change at a faster rate than citrus tree biotechnology will. Nonetheless, production and non-production agricultural technologies are changing also, sped along by hypercommunications, education, and research. One example given in Chapter 2 is the recent AP story "Biotech pigs grow 40 percent faster, larger." [Associated Press, December 7 and December 8, 1999] Thus, for growers who seek innovative new technologies (or invent them)[19], there can be substantial payoffs from trying to shorten supposedly fixed planting cycles.

In fact, both hypercommunications supply and agribusiness demand for hypercommunications depend heavily on technical intelligence and the management of innovation. An important part of managing any business in the information economy is the technical intelligence function. According to Ashton and Klavans, "most firms do not have formal technical intelligence programs; they expect intelligence information to emerge as a routine part of all or some staff members' jobs. On the other hand, a growing number of firms have implemented some form of deliberate technical intelligence effort in their organization." [Ashton and Klavans, 1995, p. 3] One way technical intelligence and innovation management affect agribusinesses is through hypercommunication needs based on the need to become (or remain) competitive.

6.3.3 Hypercommunication Needs Based on Competitive Strategy

Hypercommunication needs based on the need to be competitive are strategic. An agribusiness may conclude that its hypercommunication needs consist of matching what a certain competitor is already doing. Another agribusiness may decide that it has a need for a new strategy because it concludes that it will go out of business if it does not upgrade from separate legacy networks to a converged hypercommunication network. Finally, a third agribusiness may decide to lead the competition by using hypercommunications to innovate by being the first firm in the world, country, state, or county to use a particular technology or service to reach employees, customers, or vendors. In each case, the agribusiness perceives that it can increase profits, improve market share, raise revenue, or simply ensure its survival by adopting hypercommunications as part of a competitive strategy.

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[19] This line of thinking is considered in detail in section 2.3, technology, the second foundation of the information economy.

Some hypercommunications needs based on competitive strategies are unique to agribusiness while others are not. That is because hypercommunications, technology, and information (a trio of positively correlated factors) change an industry from the outside and from the inside. Importantly, if history is any judge, the dramatic changes occurring in agriculture due to all three factors will wipe out some operations, create others, and make still others much larger and more efficient. Competitive pressure due to new hypercommunication services and technologies such as the Internet, e-business, CTI, VPNs, and other high-tech changes in business networking are present in agribusiness as in other industries. However, technological developments within agriculture are responsible for hypercommunication needs based on the need to compete in areas such as precision agriculture, biotechnology, and agribusiness intelligence.

Technological changes from within Florida agriculture in the past have led to changes in the structure and number of agribusinesses. Internal technological changes included refrigeration for produce to reduce spoilage, new fertilizers adapted to sandy or clay soils, new pesticides adapted to indigenous pests and humid conditions, and new herbicides adapted to indigenous and non-native weeds. While the new internal technological change saved some agribusinesses and allowed others to be established, smaller producers (who could not afford the technology) and others (who were late to adopt) went out of business.

Similarly, technological changes from outside agriculture have led to restructuring of Florida's entire agribusiness complex. External technologies such as better transportation and air conditioning tended to change land uses to urban and bring tourism-related industries to Florida, displacing many agricultural operations. However, while these external technologies caused Florida's population to swell, new agribusinesses were established to serve the larger population, while still others moved operations to less urbanized areas. However, many smaller producers were forced out of business by external technological change as well.

Technological change brought by the information economy to Florida agribusinesses is both an internal and an external change. Just as successful urban businesses have thrived on intelligence and R&D gained through hypercommunications, so too have successful agribusinesses benefited. However, many production-oriented farms, ranches, and nurseries may be efficient producers but are inefficient at processing and receiving information. As time passes in the hypercommunications adoption process, the chance increases that some agribusinesses will become the latest casualties of technological change.

However, smallness is not an excuse to fail with hypercommunications (as it may have been with past technological changes) since benefits of hypercommunications adoption are not as restricted to large firms. As the real price of transport and access continue to fall, small operations can communicate with the outside world the way Fortune 500 firms did a few years ago. Late adopters of hypercommunications and information technology could lose out to early-adopting competitors who have had time to benefit from a growing volume of real-time information about prices, weather, and other unique characteristics of agriculture as given in Table 6-4. Competitive disparities between evenly suited competitors can develop almost overnight because of a combination of hypercommunication boundaries, regulation, and management inertia.

Additionally, the ability to communicate in volume over great distances at costs a fraction of what they were even a few years ago suggests that the amount of data reaching many agribusinesses is increasing exponentially. For information inefficient agribusinesses, increased information flows can be a disadvantage. If an information inefficient firm collects far more information than an information efficient competitor but gets lost in its superior volume, it may go out of business although it possesses the key to future profitability. Time compression may speed up this cycle.

Therefore, the unique role of information and hypercommunications as inputs, outputs, and sources of innovation mean converged networks are an increasingly important competitive tool. However, the CPE an agribusiness buys is limited not only by its budget, but also by the local infrastructure and the level of competition among carriers within the boundaries of local hypercommunication markets where it has offices. Florida has built a communications and transportation infrastructure that has ended the twentieth century nicely. Unfortunately, the twenty-first century may see some Florida agribusinesses lose out to competitors in states with more widespread high-speed network access and higher capacity transportation facilities and communications infrastructure. Other Florida agribusinesses could lose out to competitors inside the state that have better infrastructures or more competition in hypercommunications access and transport.

Hypercommunications convergence (4.1 provides several dimensions) has profound implications on defensive and offensive competitive strategies for all Florida businesses including agribusinesses. Hypercommunication needs based on competitive strategies come from four general sources:

1) How communications for all businesses are changing.
2) How local infrastructures are developing unequally.
3) How different services and technologies will be sold to Florida agribusinesses, together with QOS and carrier differences.
4) How doing business in agriculture is likely to change with convergence.

On the first source of hypercommunication needs based on competitive strategies, how communications for all businesses are changing, Chapter 2 argued that the need for hypercommunications is rooted in the information economy. The three foundations of the information economy (information, communications, and technology) were given enough treatment there (and elsewhere) to make a strong case that almost all businesses need to plan for a single converged hypercommunications network. However, since convergence is in the future, it is easy to postpone decision making while waiting for events to unfold. However, the strategy of doing nothing or making incremental decisions about an agribusiness' hypercommunication tactics can be more expensive than concerted action in the short run and could mean the business will close in the long run. Recall from Chapter 2 that time compression means that the long run and the short run go by more quickly than they used to.

The second source of hypercommunication needs based on competitive strategies, how local infrastructures are developing unequally, also was covered in detail in previous sections. Several kinds of infrastructure have been given already including the telephone infrastructure (4.3.2), the cable TV and fiber infrastructure (4.3.3), and the wireless infrastructure in 4.4. In all, ten infrastructures capable of delivering high-speed access were given in Table 5-4 in 5.2.2, but most parts of Florida are served by at most one of these. Additionally, hypercommunication boundaries (discussed in 6.1) create localized infrastructure differences so that agribusinesses as close as one mile from each other can have great variation in service availability.

While unequal infrastructure development is often considered a temporary problem, there can be no doubt that it can affect the ability to use hypercommunications to compete. Infrastructure inequality does not affect only rural areas; suburban and urban areas have great variation in infrastructures, access, and competition. Infrastructure differences can force businesses to tailor their competitive strategies for using hypercommunication according to their location. In that way, infrastructure inequality can alter competition.

The third source of competitive strategies comes from how different services and technologies will be sold to Florida agribusiness, together with QOS and carrier differences. Eventually, one transport network and one access connection will replace separate access connections to separate networks for telephony, enhanced telecommunications, private data networking, and the Internet. To be competitive and remain that way, agribusinesses will have to understand hypercommunications services and technologies and learn to determine the amount they need in their business. Thus, one hypercommunications need is to understand what services are being purchased, what hypercommunication technologies are capable of, and what QOS is. Competitive strategies based on ignorance of hypercommunication services, technologies, and costs can lead to becoming less competitive.

Chapter 4 provides a detailed treatment of services and technologies to acquaint agribusinesses with information about specific services from traditional telephony (4.6) to Internet (4.9). Dimensions of QOS are discussed in 4.2.4, with Table 4-3 covering fifteen dimensions of QOS. The competitiveness of an agribusiness depends on reliability and other QOS characteristics of its hypercommunication choices. Differences among carriers are covered in Chapter 7. The more an agribusiness understands hypercommunications, the better it can negotiate with carriers to fulfill its need to compete.

The final source of competitive hypercommunication strategies, how doing business in agriculture is likely to change with convergence, must be viewed through customer and employee eyes in addition to a purely strategic view. Based on a careful assessment of how customers and employees will react to and learn to use new communication technologies, hypercommunications can be used as a competitive weapon. However, agribusinesses must be careful to form reasonable expectations about how quickly and to what extent changes will occur.

One example of how doing business in agriculture may change due to hypercommunications is by the gradual replacement of traditional customer interaction with the Internet-based e-business model (4.9.9). There is competitive pressure for some agribusinesses to become e-agribusinesses, sometimes without considering downside risks and organizational competencies inherent in such an approach. One of the most important questions is whether the agribusiness can handle the volume of communications and information from becoming an e-agribusiness, especially whether the firm has personnel who are capable and willing to do so.

For example, the Internet is an information gathering tool and a communications network with low recurring transport costs along with extremely low variable access and transport costs[20]. However, there are fixed costs to program and establish an e-commerce site along with capital cost for the CPE (computers, telephones, fax capability, web servers, and security firewalls). There are also new risks from dealing with the unknown. System errors can be extremely costly, time-consuming, and can mysteriously re-occur although technical staff or vendors assure customers that they have been fixed. Plans for contingencies and redundancies must be made because as hypercommunications increase in importance, so does the cost of downtime. Hence, as the section on Internet services and access (4.9) argued, becoming an e-business will consume more resources than the standard business model in the short run and create new risks.

Furthermore, using hypercommunications as part of a competitive strategy requires that agribusinesses not become so enamored with hypercommunications that they forget the desires and abilities of existing customers. True, hypercommunications can save on transaction costs compared to traditional stores or traveling personal salespeople by establishing call centers and user-friendly interactive websites with interactive, responsive technical support. Indeed, the accounting and economic costs of answering an inquiry via e-mail are small compared with costs for personal sales calls, overnight courier packets, or even USPS postage. It can be tempting to expect that long-distance telephone calls and faxes will give way to e-mail overnight. However, the transition from hypocommunications to hypercommunications is often a slow process that will never be complete because not all customers wish to (or are able to) communicate in the same way. There is a risk of losing customers entirely or seeing the average sale per customer plummet if the transition is too rapid, too impersonal, or if there is not a trained, information literate staff. Customer service cannot be sacrificed in the name of the efficiency of high technology without repercussions on sales and profits.

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[20] Section 4.9 explained the full complement of Internet services and technologies. The main accounting costs for communication by Internet is RACC for the access loop (agribusiness to ISP POP) and RTR from the ISP to the Internet itself as was discussed in 4.9.1 (see Table 4-31 and Figure 4-56). The economic costs tend to appear on a traffic-sensitive basis as will be explained in 7.2 when pricing and the conceptual model are combined.

The term pioneer advantage is often used to suggest that a competitive advantage accrues to the first innovator, but there is a vigorous debate about whether pioneers actually have advantages [Goldner and Tellis, 1993]. Indeed, some argue that with many high technologies, there is a long record of pioneer disadvantage. In many cases, the earliest adopters failed and their mistakes were exploited by an "early middle" who carefully observed what went wrong and, with the benefit of another firm's hindsight, avoided the missteps taken by the pioneers. To Stone the belief that technology alone can turn a bad business model around is an example of a phenomenon Friederich Hayek called 'synoptic delusion' [Stone, 1997, p.9].

It is important to keep a cautionary eye open to competitive disadvantages that can occur from using hypercommunications as a competitive tool. As the agricultural marketing chain develops into a specialized network to take advantage of positive network effects, it is important to realize that network effects can be negative as well. The next three sub-sections consider the interaction between hypercommunication needs and how doing business in agriculture will change due to information technology and networked hypercommunications.

6.3.4 Needs Based on Vertical and Horizontal Coordination and Integration

Hypercommunication needs depend on vertical and horizontal coordination and integration in the agribusiness complex. Table 6-4 (and the discussion in 6.3.2 regarding the uniqueness of agriculture) mentioned some examples of specific hypercommunication needs based on an agribusiness' position in the distribution chain. This sub-section expands on the previous discussion by considering hypercommunication needs that stem from networks of vertical and horizontal integration and coordination in agribusiness. Additionally, some argue that new diagonal networks (necessitated by the growing importance of information and hypercommunications) are causing the two-dimensional agricultural marketing chain to evolve into an innovative, multi-dimensional mega network [National Council for Agricultural Research, 1998].

Thus, the hypercommunication needs of an agribusiness depend on two important marketing chain factors: dimensions and span-of-control. There are three dimensions to the agribusiness marketing complex: vertical, horizontal, and diagonal. Span-of-control may be either coordinated or integrated. Before covering general and specific hypercommunication needs based on the dimension and span-of-control of a particular agribusiness, it is important to establish the meaning of each factor.

On the vertical dimension, vertical integration occurs when one firm "controls the flow of a commodity across two or more stages of food production." [ERS, AIB-720, June 1996, p. 1] Vertical market coordination entails "clear and distinct price signals transmitted by the marketing system among the stages and particularly to producers and to buyers" [Branson and Norvell, 1983, p. 100]. Vertical market coordination also includes orderly and efficient movement of products from one level (or stage) of the marketing chain to another. The difference between vertical market coordination and a vertically integrated firm is that a single firm accomplishes integration while markets and other institutional networks of many different firms are needed for coordination.

Vertical coordination between the producer level and higher levels in the marketing chain may be accomplished in two ways. The traditional method, open production, occurs when a firm buys commodities from producers for a market price determined at the time of purchase. Open production makes information about real-time prices and price discovery especially important to producers and non-production agribusinesses alike. Contract production, a second form of coordination, occurs when a firm contracts to buy commodities from a producer according to a price agreed upon when the contract is signed before the purchase is actually made.

There are two types of contracts between producers and commodity buyers. One type is the production contract (where the contract stipulates a specified quantity and quality to be sold by the farm, but the contractor and not the producer owns the crop, pays for inputs, and makes most production decisions). A second kind of producer contract is the marketing contract, where a negotiated price (or range of prices) is agreed upon along with a specific quantity or quantity range. However, the marketing contracted producer owns the crop, pays for inputs, and makes production decisions. While only 11 percent of farms had either type of contract in 1993, contracting operators accounted for 40 percent of farm product sales; though some 27 percent of sales from contract farms were sold outside of contract [ERS, "A Close-up of Changes in Farm Organization", 2000]. Production contracts are especially common for poultry operations while marketing contracts are more common in cash grains, vegetables, fruits, and dairy operations.

On the horizontal dimension, integration and coordination relate to how a single level of the marketing chain is organized. Horizontal integration implies that one firm controls the activities of many other firms, locations, or products in the same line of business, at the same level of the marketing chain. Horizontal coordination occurs when firms at a particular level of the marketing chain participate in markets, cooperatives, and other institutions in order to allocate resources and to move products efficiently.

The diagonal dimension arises when agribusiness firms and firms in other industries exploit positive network effects to create new, interdisciplinary markets [Hinterhunber and Levin, 1994]. Typically, the diagonal dimension is expressed through a strategic partnership where diagonal coordination occurs between firms in different industries. However, diagonal integration can occur when one firm controls its strategic partner in another industry. A strategic partnership between a grocery retailer and an e-commerce software and networking services company in a joint venture of an online grocery store would be an example of diagonal coordination.

The levels or stages of the marketing chain make up the vertical dimension. Branson and Norvell identify nine stages of agricultural marketing and two supplementary marketing services that comprise the vertical marketing chain. These are given in Table 6-5 where each stage is identified along with examples and the marketing functions of each stage. Integration and coordination in agribusiness are complicated by the fact that the marketing stages and functions can vary among specific commodities. For example, the citrus, dairy, and vegetable industries have differences in the functions accounted for by vertical levels. Therefore, Table 6-5 is a general representation of stages.

Hypercommunications and better information are responsible for a general trend called channel collapse where some intermediate levels of the marketing chain (often called middlemen) become obsolete or unnecessary due to information technology and inexpensive and improved communications. As raw commodities become increasingly tailored to processing (so that discriminating customers may obtain specific characteristics), direct communication between processors and producers or between processors and consumers is increasingly important [ERS, AIB-720, June 1996]. Assemblers and wholesalers who only profit from wide, generic product lines are endangered by channel collapse especially since middlemen can actually interfere with the satisfaction of consumer wants because they represent an additional level of communication.

Channel collapse occurs with search goods. Search goods are goods that consumers (or firms at other stages in the marketing chain) are willing to spend time searching for information on. Often, search goods have been equated with big-ticket purchases where the cost of searching is worthwhile. Two trends enlarge the number of search goods in agriculture. First, food safety, and concern over organic foods, biotechnology, and humane animal production increase the amount of information searching customers find worthwhile. Second, the cost of information seeking is falling while the ability to automate the search process rises. Hence, individual consumers may be willing to seek new retailers and new channel members may take advantage of the demand by bypassing tradition-bound channel structures in favor of new arrangements now made possible by improved communications.

Table 6-5: Stages in the agricultural marketing chain

Stage	Examples	Functions
1. Assembly of raw commodities	Commodity buyers, grain elevators, packing houses, cotton gins	Brings raw commodities produced by many firms into uniform lots.
2. Transportation	Trucking carriers, airfreight of perishables, water and rail transport.	Move products between stages to right place at right time.
3. Storage and warehousing	Refrigerated warehouses, atmosphere controlled warehouses, heated warehouses, freezer warehouses.	Move product through time, match seasonality of supply to demand seasonality,
4. Grading and classification	Normally part of storage or assembler, grades, and standards set by trade or USDA.	Find value of a lot for end users. Ensure quality standards.
5. Processing	Fruit and vegetable canning and freezing plants, meat packing plants	Convert raw commodities into salable form for consumers or processing.
6. Further processing, manufacturing, product development	Food manufacturing plants	Create finished, ready-to-eat, or other convenience goods.
7. Packaging	Makers of boxes, plastic wrap and bottles, and other containers for food products.	Protect product; provide convenience for shippers, retailers, and consumers.
8. Distribution (wholesaling)	Independent wholesalers who market products to retail distributors, retail distribution centers, exporters.	Selling, organizing transporting, and financing shipments to retailers, HRI.
9. Retailing	Food stores, HRI	Sell or prepare finished goods for final consumers.
Supplemental marketing services		
Futures, options, and forward markets	Futures contracts, options on futures, forward contracts traded on organized exchanges.	Transfer of price risk between hedgers and speculators
Credit and banking	Banks, farm lenders.	Short-term to long-term credit on products, equipment, and land.
Insurance	Crop insurance, flood insurance, custom insurance	Transfer of other risks.
Hypercommunication networks	Web sites, e-commerce sites, virtual networks, price bots.	Provide information, communication, and markets.

Source: Adapted from Branson and Norvell, 1983, p. 59.

However, before getting into specifics, each vertical stage in Table 6-5 has general hypercommunication needs as well. Figure 6-21 shows four quadrants that are based on the horizontal-vertical distinction and span-of-control. However, the position of an agribusiness in a quadrant does not mean its needs are identical to others in that quadrant since other factors influence hypercommunication needs. In Figure 6-21, horizontal needs are based on integration; for example, whether the agribusiness has one or many locations in which it does business. The term location includes more than physical offices or farms; it also involves salespeople on the road, production personnel scattered over a single site, SOHO workers, and cybercommuters.

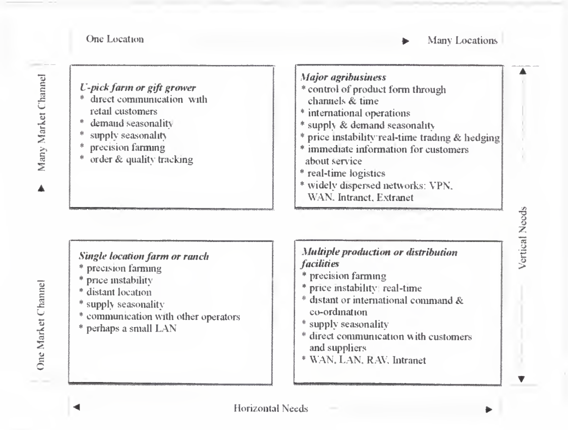
One Location
Many Locations
Many Market Channel
One Market Channel
Vertical Needs
Horizontal Needs
U-pick farm or gift grower
* direct communication with retail customers
* demand seasonality
* supply seasonality
* precision farming
* order & quality tracking
Major agribusiness
* control of product form through channels & time
* international operations
* supply & demand seasonality
* price instability real-time trading & hedging
* immediate information for customers about service
* real-time logistics
* widely dispersed networks: VPN, WAN, Intranet, Extranet
Single location farm or ranch
* precision farming
* price instability
* distant location
* supply seasonality
* communication with other operators
* perhaps a small LAN
Multiple production or distribution facilities
* precision farming
* price instability real-time
* distant or international command & co-ordination
* supply seasonality
* direct communication with customers and suppliers
* WAN, LAN, RAV, Intranet

Figure 6-21: Vertical and horizontal agribusiness communication needs.

The upper right quadrant in Figure 6-21 represents agribusinesses that are both vertically and horizontally integrated. While such firms are usually large multinational corporations, hypercommunication needs based on such an integrated form depend on more than just the size and geographical distance of communications.[21] Better communications allow the integrated firm to monitor and control operations better. Even large firms cannot get rid of supply and demand seasonality. However, if the horizontally and vertically integrated operation has an intelligence gathering and analysis capability, it may be better prepared to work around instability. Price risk may be countered through better information along with real-time trading and hedging, requiring Internet connections with high reliability along with an understanding of the strengths and limitations of the online broker to be used.

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[21] Hypercommunication needs based specifically on firm size and marketing area are covered in 6.3.6. They are related to but not the same as needs due to vertical and horizontal integration.

Another hypercommunication need is to provide customers real-time customer service information as well as having such information available for internal movement of goods inside the firm. Data communications are important for interfirm communications, while outside customers may rely on voice communications more. External and internal communications may occur more efficiently, with greater choice of message type, and lower costs through CTI (computer and telephone integration). The discussions in Chapter 4 about voice-data consolidation (4.5.4), call centers (4.7.2), and VPNs and converged networks (4.9.7) are especially aimed at horizontally and vertically integrated firms. Superior integration requires real time logistics possibly with QOS SLAs (guarantees) from hypercommunication carriers because downtime becomes especially expensive if the firm's strength is in its integration. Due to the importance of internal communications that are also secure, WANs, Intranets, and VPNs are likely to be used by agribusinesses in this quadrant. Distributed client-server networks (3.5.5) and inter-networks or Intranets (3.5.6) are likely to be the most successful network design by firms in this quadrant.

The lower right quadrant in Figure 6-21 shows agribusinesses with few channels but many locations, the classic case of horizontal integration. Examples of such firms can be found at all levels of the marketing chain, including transportation carriers and wholesalers, retailers, and other firms with multiple production or distribution facilities. At the producer level, single farming or livestock operations who operate dozens of large farms scattered over the United States and the world are a prime example. Horizontally integrated firms need secure, reliable, and inexpensive data and voice communications to connect their locations. Additionally, they must communicate with vendors and customers in other vertical levels of the agricultural marketing chain and outside of it.

Needs vary according to the marketing level and the specific product produced and handled. However, such horizontally integrated operations may operate at scales where they can afford sophisticated precision farming and multiple-location logistical systems. While multiple locations may diversify price risk, large operations still face price instability and need real-time information about prices, supplies, and demand. If the horizontally integrated firm is not a retail or wholesale operation, it may be especially concerned with seasonality of supply. Multiple location farms can use hypercommunications for yield monitoring, harvest staffing, scheduling, and monitoring, and for precision agriculture and remote sensing applications. An organization with such a large footprint may have a difficult time coordinating communications with marketing levels above and below it, something an Extranet could help with. Extranets are becoming particularly important in shipping and transportation, as well as for agribusinesses that sell to retail chains. The firm might benefit from having an Intranet to maintain privacy of horizontal communications as part of a WAN. LANs may be important at individual locations, though for some horizontally integrated agribusinesses, Remote Access Vehicles (RAVs) are important since employees may be so dispersed that each one is in a different location.

The upper left quadrant of Figure 6-21 shows agribusinesses with few locations but many channels. This quadrant represents what might be called single-location vertically integrated firms. Examples might include gift fruit growers and shippers and U-pick operations or other producers who engage in direct marketing. Producers who create side businesses (such as bed and breakfasts, guest ranches, or other agri-tourism such as hunting and fishing packages) are included here as well. Hypercommunications for these firms require direct communication with retail customers. Such operations are subject to demand seasonality and seasonality of supply but must manage seasonality themselves.

Direct marketing by farmers is seen as an excellent opportunity for producers to remain in farming by using channel collapse to their advantage [USDA AMS, 2000]. However, for producers who start U-pick or tourism operations, establish gift or home cooking businesses, or plan to market commodities directly to wholesalers or retailers, information and communications become more important. Retail customers may require order tracking, quality control, and may need plenty of information and ask frequent questions. Government regulations and permits, changes in insurance, and the need to learn new skills lead to the requirement for new kinds of information, something the Internet can deliver inexpensively.

Such firms may need a LAN, but are likely to require hypercommunications for external communication since they do not have extensive horizontal communication needs. The telephone and the Internet are especially important for establishing relationships with customers, learning about what similar operations are doing, as well as directly taking orders from consumers and tracing them if needed. For very small operations, at least a website, an e-mail address that is checked frequently, a fax machine, a credit card POS approval terminal, and some extra telephone lines (possibly with voice mail) are likely to be important.

One advantage of hypercommunications technologies and services is that they can be labor savers for small businesses as well as larger ones. A website can take orders and answer a large volume of customer questions through FAQs on websites or by auto-response e-mails[22]. E-mails and voice mails can be sent and received 24 hours a day at the convenience of customers and the agribusiness. Businesses with as few as six employees can service hundreds of customers a week, provided they have the communications capacity to deal with sudden day-to-day spurts of orders and "normal" seasonality accompanied by frequent dry spells. Firms can hire fulfillment services to take orders and ship them instead of trying to plan employment and communication capacity around instability.

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[22] The pros and cons of e-mail autoresponders are debated in 4.9.2 where e-mail is covered.

For single location, vertically integrated producers with retail tourism or commodity sales or for those with wholesale-retail activity, enhanced telecommunication services and technologies (described in 4.7) become cost effective once the number of analog telephone lines reaches eight or ten. If their website is hosted by a hosting company (see 4.9.3) and Internet, fax, and voice traffic are combined onto a unified high-speed, variable-capacity connection, then small companies can reap multiple benefits. They can communicate in greater volume, with a larger choice of message types, over longer distances, and at less cost than they can with multiple telephone lines. However, a considerable investment by the agribusiness in CPE may be needed.

The lower left quadrant in Figure 6-21 shows agribusinesses with a single location at a single stage of the marketing chain. Many family farms and small production operations fit in this area. With the exception of nurseries and greenhouses, operations in this category are the most likely to be dependent on the vagaries of rural infrastructures and variances in availability due to hypercommunication boundaries. Single location farms and ranches need to communicate with vendors and customers, but they also benefit by communicating with each other.

Hypercommunication needs are closely allied with information needs. Klair, Boggia, and Richardson argue that farmers in the information age have several information needs. These include farm management, risk management, government programs and extension services, quality production, technical information about cultural practices such as organic farming, pest management BMPs (Best Management Practices), marketing and advertising management, and new technology evaluation and introduction [Klair, Boggia, and Richardson, 1998]. CNN Interactive reported that the farming industry was being "rocked by the Internet" with specialized web auctions of a variety of farm products and web sites that allow farmers to buy inputs ranging from cattle embryos to used farm equipment [Frauenfelder, 1999].

However, while Internet access and computer ownership are advertised as being vitally importance to individual producers, as recently as July 1999 a majority of farms in Florida were without a computer. According to USDA NASS, 45 percent of Florida farms had computer access in 1999, up from 41 percent in 1997. In Florida 39 percent of farms own or lease a computer in 1999, while 27 percent of those use computers for farm business. The number of farms with Internet access jumped from 19 percent in 1997 to 34 percent in 1999.

If the farming industry is being rocked by the Internet and farmers have so many information age needs, one might expect to see higher computer and Internet penetration. Not surprisingly, one reason for the apparent paradox is that farm size matters. The NASS data showed larger farms were more likely to own computers, to use them in farm business, and to have Internet access. In 1999, 64 percent of farms in Florida with over $100,000 in sales had access to computers, 56 percent of farms owned or leased computers and 40 percent used computers for farm business. Among Florida farms with over $100,000 in sales, 42 percent had Internet access in July 1999, compared with 21 percent in July 1997 [USDA NASS, "Farm Computer Usage and Ownership", 1999]. It is possible that operators of smaller operations are too busy, subject to poor rural infrastructures, or lack the skills or assets needed to buy computers and Internet access. It is important to realize that while there are scales of operation for some hypercommunication services, hypercommunications can be packaged so that small farming becomes more viable.

Many studies have sought to learn more farm penetration of computers and the Internet along with more about the kinds of farmers that adopt new technology and their information needs [Baker, 1989; Peña, 1999; Gwin and Lionberger, 1993; Daberkow and McBride, 1997; Jones and Mishoe, 1982, IFAS, 1982; Lionberger and Gwin, 1982, Webb, 1982; Ferguson and Israel, 1999; Wu, *et al.*, 1999; Hoag, Ascough, and Fraiser, 1999]. Another reason often cited for relatively low computer and Internet penetration on farms is age. The average age of U.S. farm operators is increasing, reaching 54.3 years in 1997, up from 53.3 years in 1992 and 50.5 years in 1982 [NASS, *1997 Census of Agriculture*, 1999]. Both computer penetration and Internet use fall as age rises. Indeed, the situation may not be very different than it was for other cases of technological change. Larger farms with younger owners more willing to take risks adopt new technology early, then end up buying the operations of their more reluctant neighbors who end up not being able to fight the technology treadmill [Tweeten, 1989].

Regardless of the rural sociology of adoption behavior, agribusinesses in the lower left quadrant of Figure 6-21 have unique hypercommunication needs based on vertical communication with buyers and vendors and horizontal relationships with other producers. Internal communication needs might require a small LAN and some mobile communications to keep the operator in touch with his office as he works. However, many of the seven new needs for information (identified by Klair, Boggia, and Richardson in 1998) can be or are being met by the Internet.

Farm management is one area where computers have been used for years. Mainly the computer has been used for BackOffice duties such as accounting, payroll, and similar chores using spreadsheets or similar all-purpose software. Now, highly specialized packages such as CitrusPro software (www.citruspro.com) are available in separate modules for tracking harvesting and yields, managing groves, and for citrus processors.

However, farmers use the Internet along with remote sensing hardware to tell them when (and precisely where) chores such as irrigation and fertilization need to be done. Precision farming techniques such as these can be enabled by aerial mapping data and computer mechanization of farm hardware to identify problems and opportunities farmers and ranchers might otherwise miss. Precision farming and computer mechanization are new technologies designed to help farmers with their needs for farm management information and quality production information, (as well as being capable of actually doing work). One reason farmers have a third information need (for new technology introduction and evaluation) is because of developments in this area.

Hypercommunication needs include better information about price discovery and instability, along with supply seasonality. The Internet is already helping with the need for risk management information. However, using the Internet can require considerable information literacy. The Internet offers online futures trading for hedgers and numerous free sites with information about weather, prices, international competition, etc. Information about weather risks is more available. Farmers can be awakened by weather radios if a freeze warning is declared at midnight or alerted to impending severe weather such as tornadoes and hail. Such information can be transmitted free to pagers, wireless telephones, fax machines, or e-mail addresses automatically through the National Weather Service's EMWIN system.[23]

Subscription services such as AgCast and FarmDayta's AgDayta service are designed to help busy farmers find exactly the information they need from the Internet but lack the time to search. Farmers no longer need to leave the farm since they can use e-commerce and auction sites to purchase equipment, feed, and other inputs, and even get farm loans online from farmcredit.com, the website of farm Credit Services. Not all farm supply firms plan to create B2B websites to sell directly, because it is thought that online sales are not tailored to local conditions and cannot provide the information and personal relationships that sales representatives and dealers can. However, most suppliers do offer farmers the ability to get detailed information about highly technical products such as chemicals, equipment, fertilizer, and seeds online as well as offer product support by e-mail, special websites for customers, and other information.

Needs for information about government programs, Extension programs, cultural practice information, and new technologies are also available from free web sites such as the very general www.agriculture.com and the very specific www.beekeeping.org. Farmers benefit from being able to meet other producers all over the world and communicating with them directly in chat rooms, USENET news groups, bulletin boards, and other online networking settings. Of course, a single operation may benefit from hypercommunications in other ways as detailed throug hout this section and Chapter 4.

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[23] Information about EMWIN is available at http://iwin.nws.noaa.gov/emwin/winven.htm.

Another way of analyzing the unique hypercommunication needs of agribusinesses based on vertical and horizontal co-ordination and integration is by using empirical data. Multiplier data are perhaps the best available data. While such data have drawbacks, they can be useful in roughly quantifying the importance of hypercommunications within broadly defined segments of agribusiness. National Department of Commerce BEA (Bureau of Economic Analysis) multiplier data for 1996 serve as proxies for the importance of hypercommunications in Florida in 2000. While these data are for broadly-defined segments of agribusiness, are at the national level, and are old as far as new hypercommunication technologies are concerned, they provide an idea of communications share of budget data for different firms.

Data for calendar 1996 on the relative importance of communications has been prepared by the BEA (Bureau of Economic Analysis) as part of annual Input-Output multiplier data [Okubo, Lawson, and Planting, 2000]. Multipliers associated with three industry categories communications (excluding broadcasting), computer and office equipment, and data processing services can be combined to arrive at an idea of the importance of hypercommunications in general. The importance of data communications alone is illustrated by the second two categories, while the communications multiplier alone is a proxy for the importance of voice communications. Multipliers can be used to examine the importance of hypercommunications both as a production input and as a factor contributing to total revenue. Therefore, the importance of communication *down* the marketing chain can be compared with the importance of communication *up* the marketing chain.

Table 6-6 shows rankings of direct requirement coefficients based on their combined share of intermediate inputs. These values show the amount of communications (alone or combined with the two computer categories) required to produce one dollar of industry output for different levels of the distribution chain. The combined share of inputs column shows the share of purchased inputs of the row industry accounted for by a combination of communications, computer and office equipment, and computer and data processing services, a proxy for hypercommunications.[24] The communications-only column shows the share of purchased inputs represented by communications alone, a proxy for voice communications. The ratio of the combined share to the communications-only share is one way to express the importance of data communications versus voice communications. The higher the data ratio in the last column, the higher the need for converged networks might be expected to be, unless all data equipment is used solely on premises.[25]

Both columns are crude ways of showing the direct requirement of hypercommunications[26] from the row industry *down* the marketing chain. For example, the share of purchased hypercommunication inputs for air transportation is 6.2%, while for communications alone the share is 2.1%, a ratio of 2.95:1, suggesting that data communications are more important to production than voice. For livestock and livestock products, the share of purchased hypercommunication inputs is 0.288%, while for communications alone the total is 0.283%, a ratio of 1.01:1, suggesting that data communications have little importance in production. Not surprisingly, the share of the air transportation industry's costs accounted for by communications is considerably higher than that for livestock products.

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[24] To obtain the shares (which are expressed as percentages), the direct requirement coefficients for communications, data processing, and computer equipment were added up. That sum was divided by the total intermediate input share (1 minus the value added by the agribusiness or transportation sector under examination) to yield the the combined share of inputs column.

[25] Businesses who are the best candidates for convergence are likely to have established high-capacity (T-1 or higher) data communication networks. These interconnect with the firm's telephone network using right facilitating technologies (4.5.4) and CPE (4.7.2, 4.8.1). However, communications scale is not part of national level NIPA BEA I-O multipliers. The multiplier data only show shares and forward and backward linkages. However, it is likely that industries with higher shares of data CPE and processing are populated by firms large enough to afford high-capacity connections, especially as prices on CPE, access, and transport fall from 1996.

[26] Per dollar of industry output at producer prices.

Table 6-6: Share of production inputs represented by hypercommunications for various segments of agribusiness

Rank of comb. share	Stage from Table 6-5	Marketing stage industry description	Comb. share of inputs (%)	Comm.-only share of inputs (%)	Data Ratio
1	2	Pipelines, freight forwarders, and related services	26.870	6.540	4.1
2	8	Wholesale trade, all	9.315	5.810	1.6
3	2	Air transportation	6.255	2.095	3.0
4	9	Retail trade, general	5.593	3.388	1.7
5	2	Railroads and related services	5.555	1.807	3.1
6	2	Motor freight transportation and warehousing	2.683	2.242	1.2
7	9	Eating and drinking places	1.337	0.766	1.7
8	3,4,5,6	Agriculture, forestry, and fishery services	1.150	1.130	1.0
9	6	Paper and allied products, except containers	1.140	0.387	2.9
10	5,6,7	Tobacco products	1.111	0.500	2.2
11	Input	Agricultural fertilizers and chemicals	0.981	0.291	3.4
12	6	Miscellaneous textile goods and floor coverings	0.979	0.440	2.2
13	2	Water transportation	0.888	0.184	4.8
14	7	Paperboard containers and boxes	0.821	0.408	2.0
15	6	Miscellaneous fabricated textile products	0.634	0.405	1.6
16	5	Fabrics, yarn, and thread mills	0.603	0.201	3.0
17	4,5,6	Lumber and wood products	0.587	0.266	2.2
18	6,7	Apparel	0.496	0.298	1.7
19	5,6,7	Food and kindred products	0.483	0.212	2.3
20	1,3,4	Other agricultural products (non-livestock)	0.481	0.475	1.0
21	1,3,4	Forestry and fishery products	0.295	0.201	1.5
22	1,3,4,5	Livestock and livestock products	0.288	0.283	1.0

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

The top of Table 6-6 is dominated by transportation and wholesaling functions as evidenced by the stage codes based on Table 6-5. In the first levels shown, over 5% of inputs are hypercommunication related. Hypercommunications are especially important to freight forwarders, wholesale trade, and air transportation. The middle of the table is dominated by services and manufacturing levels. The bottom portion of the table is dominated by stages that are close to production or are production. Thus, communications tend to be of most importance to production for transportation and wholesale levels in the marketing chain and least important for the levels closest to production agriculture.

The ratio of the combined share to communications alone (the data ratio) varies throughout Table 6-6. It is just above one for the industries in the list that are closest to production agriculture. It is also near one for agriculture, forestry, and fishery services. The ratio is 4.8 for water transportation and larger than 2.5 for transport other than motor freight, paper, textile mills, and fertilizers and chemicals. This suggests that in 1996 at least, computers tended to be most useful in production in transportation and least important in production agriculture. Since multipliers are static, it is important to realize that relationships may have changed significantly.

Table 6-7 looks at the amount of hypercommunications needed (or direct and indirect total requirement) to deliver one dollar's worth of output of the row industry to final demand at producer prices. The figures are not expressed on an input percentage basis as they were in Table 6-6. Instead, they are expressed as shares of output delivered to final demanders. If multiplied by 100, they become cents per dollar of output the industry requires from hypercommunications (the combined column) or communications alone to deliver output to final consumers. Total requirement coefficients may be broadly interpreted as proxies for communication *up* the distribution chain.

Multipliers can be easily used and abused [Beattie and Leones, 1993]. The addition of multipliers to obtain the combined share in the direct and indirect total requirements table does leave out some second-order effects that would result if convergence had actually occurred in the 1996 data or now for that matter. However, the methodology of Table 6-7 is similar to those used elsewhere to obtain backward and forward linkages of high technology [Charney and Leones, 1995; Devlin, 1995].

Table 6-7: Total (direct and indirect) communication requirements for various agribusiness-related industries (per dollar of output delivered to final demand).

Rank	Stage from Table 6-5	Marketing stage industry description	Total req. coeff. (comb.)	Total req. coeff. (comb.)	Data ratio
1	2	Pipelines, freight forwarders, and related services	0.159	0.044	4.4
2	2	Air transportation	0.065	0.023	2.3
3	8	Wholesale trade, general	0.049	0.029	2.9
4	2	Motor freight transportation and warehousing	0.041	0.026	1.6
5	2	Railroads and related services	0.040	0.015	1.5
6	2	Water transportation	0.034	0.014	2.4
7	9	Retail trade, general	0.032	0.019	1.7
8	6	Miscellaneous textile goods and floor coverings	0.029	0.014	2.1
9	Input	Agricultural chemicals and fertilizers	0.028	0.013	2.2
10	7	Paperboard containers and boxes	0.028	0.013	2.0
11	1,3,4, 5	Livestock and livestock products	0.026	0.016	1.6
12	6	Paper and allied products, except containers	0.027	0.013	2.2
13	6,7	Apparel	0.026	0.013	2.0
14	5,6,7	Food and kindred products	0.025	0.014	1.8
15	5	Fabrics, yarn, and thread mills	0.023	0.011	2.1
16	9	Eating and drinking establishments	0.023	0.013	1.8
17	6	Miscellaneous fabricated textile products	0.022	0.012	1.8
18	4,5,6	Lumber and wood products	0.022	0.011	2.0
19	5,6,7	Tobacco products	0.019	0.011	1.7
20	3,4,5, 6	Agricultural, forestry, and fishery services	0.017	0.011	1.5
21	1,3,4	Forestry and fishery products	0.016	0.009	1.8
22	1,3,4	Other agricultural products (non-livestock)	0.014	0.009	1.6

Source: [Okubo, Lawson, and Planting, 2000, Table 5, Industry-by-commodity total requirements, pp. 66-72]

Table 6-7 shows that there is a positive correlation between the amount of processing an industry performs and the importance of communications. In Table 6-7, communications become more important to producers than in table 6-6. For example, the share of purchased hypercommunication inputs for air transportation is 2.8 cents, while for communications alone the share is 1.3 cents, a ratio of 2.15:1, suggesting that data communications are slightly more important to output than voice. For livestock and livestock products, the share hypercommunications contribute per dollar of output is 2.6 cents, while for communications alone the total is 1.6 cents, a ratio of 1.63:1. Transportation and wholesale trade still dominate the top position (again the rank by combined share), while agribusinesses in the stages closest to production show lower combined and total requirements. For air transportation, the combined amount (proxy for hypercommunications) is 6.5 cents while the communications-alone amount (proxy for voice communications) is 2.3 cents.

It is evident from Table 6-6 and Table 6-7 that, even in 1996, computers and communication were responsible for at least 1.4 cents per dollar of the total requirements for the lowest ranking industry, other agricultural products. In comparison to an input basis, where the total was less than half a percent, this is an important difference. That difference is more pronounced for livestock products. For producers, communication enters the value chain as goods move up towards final demand. It is uncertain how trends such as precision farming might alter this for non-livestock agricultural products.

Ratios of the combined requirement to the communications requirement (data ratios) tend to be lower for stages closest to production. The data ratio, when compared to those calculated in Table 6-6, suggests that data communications have more importance as output requirements than as inputs. It is possible to obtain a single number that suggests the downward or upward importance within the marketing channel for each industry by forming a ratio of all entries in Table 6-6 to all entries in Table 6-7.

The result, Table 6-8, has a simpler interpretation. Since Table 6-7 shows the upward channel linkages of hypercommunications and Table 6-6 shows the backward linkages, taking a ratio of all the values in each table identifies which direction linkages prevail for each industry. (Industries are listed alphabetically.) For example, livestock and livestock products has the highest value in the first column, 9.0. That was calculated by taking the 0.026 from table 6-7, converting it to percent of output by multiplying by 100, and then dividing by 0.288 *percent of* *input* from table 6-6. The result suggests that for the livestock industry, combined communication linkages going up the marketing channel are more important than they are going downward.

Table 6-8: Ratio of upward to downward communications in various agribusiness-related industries

Industry description	Combination ratio (up >1)	Communication ratio (up >1)	Data ratio (up >1)
Agricultural chemicals and fertilizers	2.9	4.5	*0.6*
Agricultural, forestry, and fishery services	1.5	1.0	1.5
Air transportation	1.0	1.1	*0.9*
Apparel	5.2	4.4	1.2
Eating and drinking establishments	1.7	1.7	1.0
Fabrics, yarn, and thread mills	3.8	5.5	*0.7*
Food and kindred products	5.2	6.6	*0.8*
Forestry and fishery products	5.4	4.5	1.2
Livestock and livestock products	9.0	5.7	1.6
Lumber and wood products	3.7	4.1	*0.9*
Miscellaneous fabricated textile products	3.5	3.0	1.2
Miscellaneous textile goods and floor coverings	3.0	3.2	*0.9*
Motor freight transportation and warehousing	1.5	1.2	1.3
Other agricultural products (non-livestock)	2.9	1.9	1.5
Paper and allied products, except containers	2.3	3.1	*0.8*
Paperboard containers and boxes	3.3	3.3	1.0
Pipelines, freight forwarders, and related services	*0.6*	*0.7*	*0.9*
Railroads and related services	*0.7*	*0.8*	*0.9*
Retail trade, general	*0.6*	*0.6*	1.0
Tobacco products	1.7	2.2	*0.8*
Water transportation	3.8	7.6	*0.5*
Wholesale trade, general	*0.5*	*0.5*	1.1

The figures in Table 6-8 help in understanding whether forward or backward communication linkages are most important at particular levels of the marketing chain. Numbers lower than one are italicized to isolate cases where downward communications linkages are more important that upward linkages. Food and kindred products have the highest communications alone ratio of upward to downward. Wholesale trade has the lowest of both ratios, with 0.5, suggesting that these businesses have a greater requirement for communications to search for and buy products than to transport them to final demanders.

The last column, the data ratio of Table 7-8, is a ratio of the data ratio in Table 6-7 to the data ratio in Table 6-6. This number may help isolate the direction of data communications for a particular industry. Ratios below 1.0 (suggesting a predominance of downward communication) are italicized. For example, agricultural chemicals and fertilizers have a data ratio of 0.6, meaning that data communications represent a greater share of intermediate input purchases than they do of producer value at sale. This is in spite of the fact that communications show a considerable upward skew, with a ratio of 4.5. This appears to make sense if chemical manufacturers use data communications and computers for horizontal or downward communications, perhaps for supply ordering, tracking, mixing, etc. However, since agricultural chemicals are an information intensive industry due to environmental, health, and safety concerns, the overall direction of communications is up the supply chain towards users. The combined share ratio tends to cancel these opposing directions out.

In addition to varying according to stages of the marketing channel, there is some evidence from the multiplier data that the need for hypercommunication varies by input and product characteristic. This becomes the next topic.

6.3.5 Specific Needs Based on Specific Inputs, Crops, or Product Characteristics

Hypercommunication needs also depend on the inputs needed by an agribusiness, based on specific crops it produces or handles, and on general product characteristics. Hypercommunication needs based on where specific inputs come from are especially important to operations or levels of the marketing chain that add little value. Agribusinesses that have no market power must take whatever prices the market sets for output. However, the cost of inputs (also outside of control) can make up such an important part of overhead that firms become caught in a cost-price squeeze.

Hypercommunication technologies such as the Internet and EDI (Electronic Data Interchange)[27] have the potential to lower transaction costs for inputs, enlarge the potential number of suppliers an agribusiness can choose from, and promote channel collapse. However, these positive network effects are not automatic. First, they can only be taken advantage of by organizations with the infrastructure, CPE, and information-literate employees needed for implementation. Second, it can be hard for an agribusiness to tell whether hypercommunications will be useful because implementations can be complex [Kaefer and Bendoly, 1999]. Finally, the benefits may be internalized by key suppliers who require customers to use systems as when retailers require grower-shippers or processors to use a particular system to do business with the retail operation.

The potential of new forms of supplier coordination through hypercommunications can be estimated by using BEA direct requirements coefficients (along with prevailing communications directions from Table 6-8) for six general agribusiness categories in Table 6-9 through Table 6-15. By looking at the top sources of inputs on a general industry basis, some observations can be made regarding B2B hypercommunication needs for a particular industry along with possible changes in input markets that might be brought about by hypercommunications.

Livestock and livestock products (shown in Table 6-9) include dairy, beef, and poultry in Florida, along with the horse industry. This industry has the smallest value added of the six analyzed here, meaning that margins are likely to be tight and there is a need to squeeze out cost savings when possible.

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[27] EDI is allows businesses to automatically exchange transaction information with one another. It can be implemented through IP networks such as the Internet or Extranets, or through standardized inter-firm private data networking solutions such as those discussed in 4.8

Table 6-9: Hypercommunication needs and related market implications of the top five input sources, livestock and livestock products

Intermediate input source	Input share (%)	Hypercommunication needs, market implications
Other agricultural products	31.1	B2B, better logistics
Food and kindred products	21.4	B2B, better logistics
Livestock and livestock products	10.9	Horizontal-vertical integration (Intranet, VPN), Horizontal-vertical coordination (producer associations, virtual networks, Internet), online auctions.
Wholesale trade	6.4	B2B and channel collapse
Real-estate and royalties	5.1	Some additional liquidity of land
Top 5 intermediate inputs	74.9	Overall: feedlots and packers main beneficiaries due to size, integration
Other intermediate inputs	20.0	
Value added by sector	5.0	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Table 6-9 suggests that the livestock industry obtains almost three-quarters of inputs from the top five listed sources. Overall benefits of hypercommunications may flow to larger, vertically and horizontally integrated firms through improved logistics and modest cost savings on inputs. However, delivery of feed and other agricultural products such as hay and grain, are highly dependent on shipping costs so that even large producers may not be able to shave much off of costs. In the beef sector, the Internet is becoming more important for seedstock operations as a method of displaying photographic information about breeding stock, availability, and details about breed benefits and the seedstock operation. Vertical and horizontal coordination (even among smaller producers) is helped by the Internet as well, though communication is of small importance in production. Highly concentrated operations such as dairies or the poultry industry (where production contracts are especially important) are beginning to see farm-to-wholesale data networks that keep track of many variables on a real-time basis [ERS, "A Close-up of Changes in Farm Organization", 2000].

Table 6-10: Hypercommunication needs and related market implications of the top five input sources, other agricultural products (non-livestock)

Input source	Input share (%)	Hypercommunication needs, market implications
Real estate	8.7	Internet may widen market size, better information about properties, prices could lead to greater liquidity.
Agricultural fertilizers and chemicals	7.3	Internet allows detailed information to be available online, channel collapse.
Agricultural, forestry, and fishery services	6.8	Varies. Some services might vanish; others can compete and deliver via Internet.
Wholesale trade	4.8	Coordination (Extranet), integration (Intranet, VPN)
Other agricultural products (non-livestock)	2.9	Integration (Intranet), horizontal coordination (Internet, VPN), vertical coordination (Extranet)
Top 5 intermediate inputs	30.5	Overall: Small cost savings on volume purchases, more price shopping, more choice of suppliers, channel collapse.
Other intermediate inputs	13.2	
Value added by sector	56.2	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Other agricultural products (Table 6-10) include the production, assembly, and grading and classification stages in the agricultural marketing chain. Downward communication linkages of hypercommunications are limited in this sector, with the exception of small cost savings for volume purchasers, more ability to price shop, a greater number of suppliers to choose from over a larger area, and channel collapse [Frauenfelder, 1999]. However, even though communications may be more important for marketing (as mentioned in 6.3.4 regarding single location, single marketing stage operations), the dependence on output price means savings on inputs are important.

Table 6-11 features forestry and fishery products. The importance of services to this industry could mean cost savings for doing business via networked hypercommunications. However, the high geographic concentration of forestry producers due to transportation realities could limit the ability to save on inputs if inputs must come from nearby. Seafood processors may benefit from lower input costs, increased choice due to Internet and channel collapse.

Table 6-11: Hypercommunication needs and related market implications for the top five input sources for forestry and fishery products nationally

Input source	Input share (%)	Hypercommunication needs, market implications
Agricultural, forestry, and fishery services	25.0	Integration (Intranet, VPN), coordination (Extranet or Internet), impact depends on information-content and geographical concentration of service firms.
Food and kindred products	4.6	Possibility of direct purchases (channel collapse), Extranet (coordination)
Forestry and fishery products	3.3	Integration (Intranet, VPN), horizontal coordination (Internet), vertical coordination (Internet, Extranet)
Maintenance and repair construction	2.8	Unknown
Legal, engineering, accounting, and related services	2.5	Many such services can be delivered cheaply and effectively via communication networks.
Top 5 intermediate inputs	38.2	Overall: High geographic concentration may limit importance, some savings on inputs, coordination, and integration due to networking.
Other intermediate inputs	54.9	
Value added by sector	45.1	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Table 6-12: Hypercommunication needs and related market implications for the top five input sources for agricultural, forestry, and fishery services nationally

Input source	Input share (%)	Hypercommunication needs, market implications
Other agricultural products	11.0	Lower search costs for materials.
Agricultural fertilizers and chemicals	8.2	B2B Internet, channel collapse.
Wholesale trade	3.1	Channel collapse from e-commerce.
Livestock and livestock products	2.3	Unknown.
Legal, engineering, accounting, and related services	1.4	Prices could fall due to lower cost of electronic delivery
Top 5 intermediate inputs	26.0	Overall: Information input prices fall, lower search costs for materials.
Other intermediate inputs	13.3	
Value added by sector	60.7	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Table 6-12 shows agricultural, forestry, and fishery services. Inputs for services firms are relatively less important since this category has the highest value-added of the six examined. Additionally, horizontal communication needs are lower than with other categories. To the extent that such services buy information inputs from the listed sources, hypercommunications is important. The largest agricultural, forestry, and fishery service businesses are landscape and horticultural businesses, followed by veterinary services, and then other animal services [U.S. Census, County Business Patterns, 1998].

Table 6-13 shows the input requirements of the food and kindred products industry. Food and kindred products include dairy processing plants, fruit and vegetable processors, bakeries, sugar refineries, and beverage plants. Together, these operations comprise the middle of the food distribution channel. Food and kindred products firms have the highest intra-industry input requirement share of all six industries studied here.

Table 6-13: Hypercommunication needs and market implications for the top five input sources of the food and kindred products industry nationally.

Input source	Input share (%)	Hypercommunication needs, market implications
Livestock and livestock products	17.3	Lower price risk, supply instability from better risk management tools and information, channel collapse.
Food and kindred products	16.0	Coordination (Internet, Extranet), Integration (Intranet, VPN), channel collapse.
Other agricultural products (non-livestock)	8.7	Lower search costs, greater search scope, channel collapse.
Wholesale trade	6.5	B2B, channel collapse, new vendors.
Advertising	2.5	Addition of web advertising to media budgets.
Top 5 intermediate inputs	51.0	Overall: data communication is more directed downward.
Other intermediate inputs	20.2	
Value added by sector	28.8	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Food and kindred products firms face instability from two directions. They face commodity price and quantity risks from producers as well as demand risk from consumers. While commodity quantity and price risk are important in downward communications with suppliers, unexpected recent downward trends in retail food demand have led firms to spread their demand risk downward by specialization and new vertical arrangements [Reed and Clark, 2000]. Thus, relationships with input suppliers help those in the middle of the food distribution system share supply and demand risks.

Hypercommunications can be important in this process of spreading risk. Voice communications tend to be most useful for communicating up the supply chain, while data communications are important to downward communications. Raw commodities and ingredient purchases represent the top three sources of inputs. However, commodities are increasingly taking on characteristics of branded products as they move up the chain. For example, retail demand in the produce market has increased the importance of year-round varieties, pre-cut produce, and specially packaged or branded commodities [ERS AIB-758, 2000]. Thus, middlemen and processors have to cooperate more closely to find suppliers worldwide, get information about quality and price, and improve information about risk.

One way firms are coping with risk is by widespread consolidation and channel collapse [ERS, AIB-758, 2000; Reed and Clark, 2000]. This has two important effects. First, larger, more consolidated firms may be better able to afford hypercommunications. However, even while mergers and consolidations may make internal communications more important, difficulties with merging incompatible networks of previously separate entities can be enormous. Hence, IP technology such as Intranets, converged VPNs, and similar standardized approaches to communication may become more attractive than more expensive, less compatible custom private data networking solutions.

The last category to be considered is the agriculture fertilizer and chemical industry shown in Table 6-14. Products from this industry are important inputs in two other categories as shown by Table 6-12 and Table 6-10. Production in this industry is a highly technical, potentially dangerous undertaking. Information about the origin, history, and source of ingredients are especially important as is keeping a steady stream of inputs flowing for orderly production.

The top sources of inputs in the sector are from within the industry, while the second largest source is from other chemical firms. Again, data communications tends to be more important to purchasing inputs rather than selling products, though the reverse seems to be true for voice. Converged networks would help avoid having to have dual capacities, saving firms money on communication costs. Additionally, since information is generally so important vertical cooperation with suppliers through Internet and Extranet solutions can lead to savings of money, better information flow, and, thus to reduce risk.

Table 6-14: Hypercommunication needs and market implications of the top five input sources of the agricultural fertilizers and chemicals industry nationally

Input source	Input share (%)	Hypercommunication needs, market implications
Agricultural fertilizers and chemicals	11.8	Information to document regulations, safety, and health are especially important. B2B for chemical ingredients, horizontal integration requires Intranet or VPN.
Industrial and other chemicals	10.3	Vertical cooperation (Extranet), channel collapse.
Crude petroleum and natural gas	7.3	Price instability can be helped with better access to exchanges.
Motor freight transportation and warehousing	5.4	Communications needed for logistics support, Extranet with carriers.
Wholesale trade	5.2	B2B, channel collapse, more possible vendors.
Top 5 intermediate inputs	40.0	Overall: Data communication used more for input purchases than to deliver final goods.
Other intermediate inputs	26.7	
Value added by sector	33.3	

Source: [Okubo, Lawson, and Planting, 2000, Table 3, Commodity-by-industry direct requirements, pp. 66-72]

Another group of needs is based on specific customer and product characteristics. Table 6-15 shows several factors that make hypercommunications especially worthwhile. One of the most important characteristics is the unit price of a sale or product. This has been especially true of the Internet, but likely will help usher convergence in for firms as well. A single customer who buys an expensive thoroughbred racehorse or property that was found on a website can pay the entire cost of website hosting and development. High-ticket goods can be featured using detailed descriptions, images, audio, and even video using hypercommunications to interest prospective buyers without the need to invest time and money qualifying buyers.

Participation in auctions and exchange markets (such as futures markets) is enhanced by interactive, real-time communications with a variety of message types. Experiential goods such as tourism may require that retail customers have plenty of information about the facility or tour before making a reservation. An illustrated web site with plenty of detail about accommodations, food, etc. is increasingly important. Complicated order processes can be controlled and explained to customers in a uniform manner via e-commerce sites, for example. However, it is important to heed the advice given in 4.9 regarding web design and e-commerce, because a poorly designed, poorly tested site at on an overcrowded server provides headaches rather than benefits.

Most services (especially information-intensive ones) favor the use of hypercommunications. It is easier for agribusinesses to hire attorneys, accountants, brokers, and others at the best price if they have a large choice. Easily shipped products are another example of a product characteristic that makes hypercommunications more important to agribusinesses. Logistics such as scheduling and tracking can be automated and made available to customers and employees. Complicated products on the seller's end (that require logistical support) or on the buyer's end (that solve problems) increase the importance of hypercommunications networking.

Business computer needs are often separated by Microsoft into FrontOffice (sales and marketing) and BackOffice (support and administration) needs. Data intensive or time consuming operations for both cases can be outsourced to a service company that specializes in payroll or order fulfillment, for example. Outsourcing frees the agribusiness to focus on its business or to handle sudden seasonal business changes without hiring permanent help, but requires communications to transmit and receive data as well as to monitor outsourcing quality. Customer needs that merit greater hypercommunication needs also include complicated products, consumers with high (or specialized) information needs, price shoppers, search goods, and international trade. These latter customer characteristics given in Table 6-15 should be self-explanatory.

Table 6-15: Customer or product characteristics that increase the importance of hypercommunications

Characteristic	Agribusiness examples (hypercommunication advantages)
High unit price of item	Real estate, horses, breeding stock. (Pre-qualify prospects at low cost.)
Auctions, exchange markets	Internet auctions of cut and live flowers, landscape plants, animals, soybeans. (More efficient markets.)
Experiential goods	Agri-tourism, eco-tourism, recreational tourism. (Pre-qualify prospects, sales.)
Complicated order processes	Automation of complicated ordering processes without using agribusiness labor. (Avoidance of mistakes.)
Services	Sales agents, lawyers, accountants, public relations. (Larger pool to choose from.)
Easily shipped products	Expansion of market area has fewer limits with cheaper, global communications. (Savings in time and money spent on travel, shopping.)
Scheduling, tracking, logistics	Perishable shipments. (Information about where a shipment is, when it was sent or received, how long in transit, etc. promotes control.)
Problem solving goods and services	New technologies and processes that solve a problem but require information for customers to understand the concept.
BackOffice outsourcing	Payroll, bookkeeping, employment services, and other services free agribusinesses from time-consuming chores; can be purchased and monitored over Internet or Extranets. More choices exist as well since outsourcing vendor does not need to be nearby.
FrontOffice outsourcing, fulfillment services	Outsourcing ordering, shipping, other sales and marketing jobs to a specialized firm to handle seasonal needs. (Agribusiness is freed to focus on core competency.)
Complicated product	Agricultural chemicals, technologies. (Provide uniform, accurate information about safety and use.)
Customers with high information needs	Some customers prefer to have multiple methods of communications. Others will only buy or communicate via web, fax, telephone. (Serve customers they way they like.)
Price shoppers	Businesses that compete on price. (Pricebots can be programmed to search for the lowest price of any good or service on the Internet. Price conscious customer needs met)
Search goods	Recall these need not be high-ticket goods alone. Retail examples include: food safety, nutrition, organics, humane production, biotechnology, kosher, specialty items.
International target market	Ability to translate languages automatically, communicate inexpensively worldwide. (Source of new customers.)

Other hypercommunication needs are based (or will be) on specific crops. While this subject is too involved to treat in detail here (since each crop may use different parts of the same marketing channels or crop complex), it is possible to summarize two points. First, the relative importance of various crop complexes to Florida's total agribusiness complex can be approximated. Second, a few general observations can be made about how hypercommunications will influence agribusinesses dealing in specific crops.

On the first point, the extent and composition of the agribusiness hypercommunications market, both Figure 6-22 and Figure 6-23 provide a breakdown of the contribution made by segments of production agribusinesses to cash receipts [USDA NASS-FASS, "Farm Cash Receipts and Expenditures", August 2000]. Under this first definition of production agriculture, citrus is the largest sector in cash receipts, followed by vegetables and melons, livestock, and field crops.

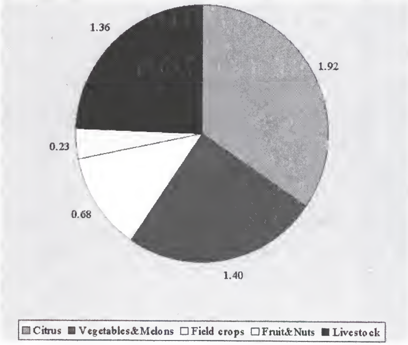

Figure 6-22: 1999 Cash receipts by category under traditional definition of production agriculture (billions of dollars).

However, the traditional definition of production agribusiness (shown in Figure 6-22 and shown in Figure 6-23 as definition one) excludes nursery and greenhouse crops. The nursery and greenhouse sector (which also includes sod and mushrooms) includes two main categories: first, foliage and floriculture, and second, greenhouse, mushrooms, and sod. Foliage consists of interior plants, while floriculture includes fresh flowers and cut flowers. When included in the total, nursery and greenhouse crops are almost as important as citrus to producer cash receipts statewide. They are especially important to South Florida and the Orlando area as Table 6-2 showed in 6.3.1.

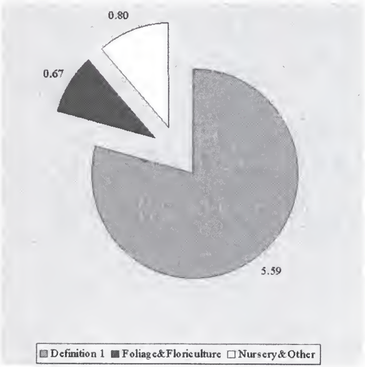

Figure 6-23: 1999 Cash receipts of nursery and greenhouse production not included in the traditional definition of production agriculture (billions of dollars).

Table 6-16 provides a further breakdown of producer receipts by specific crop (ranked in order of 1999 cash receipts).

Table 6-16: Possible hypercommunication implications on specific crop sectors in Florida

Crop or livestock sector	Production receipts, 1999 ($ Mil.)	Impact of hypercommunications on crop sector (websites with more information)
Citrus	1,920	Possible channel collapse, increased risk management tools for growers, processors. (www.ultimatecitrus.com)
Nursery, greenhouse, sod	1,459	New ways to communicate rapidly changing prices and availabilities, segregated by wholesale and retail customers. (www.growit.com, www.findplants.com, www.zone10.com, www.pbwga.com)
Sugarcane	520	Perhaps minimal due to concentration, increasing vertical integration. (www.ussugar.com)
Timber harvest	430	Most important at processor and product level. (www.timber.org, www.afandpa.org)
Milk	411	Important for input purchases, communication among producers. (www.dairybusiness.com).
Other vegetables and melons	399	Greater importance of branding, organics, retail slotting allowances, and channel collapse. (www.BuyProduce.com)
Tomatoes	392	Similar issues with other perishables. (www.agex.com's www.tomatoex.com has been introduced as an online tomato exchange).
Seafood landings	390	Most important for recreational boating or processors. (Independent trading exchange www.seafood.com, boat and equipment purchases www.marineweb.com)
Poultry and eggs	355	Makes it easier for poultry companies to monitor and enforce production contracts at producer level. (www.eggs.org) Favorite target of animal rights advocates.
Cattle and calves	310	Varies by size of operation and marketing level. Important for B2B input purchases, information for producers, communications among producers. (www.cattleinfonet.com, home of online video cattle auctions)
Green peppers	225	Similar to vegetables and melons. (www.TradingProduce.com)
Field crops other than sugar	165	Most important at broker levels and above. (www.peanutusa.com)
Snap Beans	155	Similar to vegetables and melons. Associations important, such as FFVA (www.ffva.com).
Strawberries	151	Similar to other perishables. (www.straw-berry.org
Potatoes	124	Producer source of information, increasing importance of biotechnology.
Horses and mules	114	Diverse mix of small operations, recreationalists, thoroughbred farms with their own needs. Non-feed input purchases increasingly important and international. (www.horseweb.com) Information needs of horse owners.
Sweet Corn	106	Similar to vegetables and melons.

Sources for receipts: USDA NASS-FASS, "Farm Cash Receipts and Expenditures", August 2000, Bureau of Seafood and Aquaculture Marketing, 1999; DOACS, *Florida Agricultural Facts*, 1999, p. 71

The table provides only a broad first approximation of the overall importance of each crop complex to Florida agribusiness as a whole. This is because each has a unique entire marketing channel. For example, some crops grown in Florida are processed outside of Florida, while others are grown in other states (or internationally) and processed here. The relative importance of receipts helps to focus attention on what crop complexes gives some hypercommunication implications for the top crop complexes.

Details for most of the points above have been explained more fully in previous sections, but are summarized in the table to underscore that the impact of networked hypercommunicat ions affects specific Florida crop sectors differently. A few general observations are in order. The importance and effect of hypercommunications on a crop sector is related to the total number of producers or firms, the variety of crops within the sector, and the number of uses and customers. For example, there are far more horse owners than snap bean farmers nationally as well as in Florida, so there is more overall information. Snap beans share their market chain with other vegetables while the recreational horse market, thoroughbred farms, feed, and tack, veterinary specialties, stalls, corrals, insect control and other items are a whole complex of products directed to the horse.

For several crop sectors, web sites that represent the implications of hypercommunications are included that will be better sources of specific examples. Among those listed in Table 6-16 are sites where farmers meet and communicate, sites where wholesale and retail customers can order products and get prices. Others are completely new forms of electronic markets where video auctions and real-time interactive bidding, occur and availabilities are announced. Even within crop sectors, some hypercommunication needs depend on how large an agribusiness is and how large its marketing is or can become.

6.3.6 Needs Based on Firm or Sector Size and Marketing Area

As firms grow in size, the amount of information coming in and going out rises to the point that new employees must be hired in order to keep up. Under such an information-employee growth cycle, unless new telephone lines, faxes, and computers are bought (along with an expansion in the number circuits), there will be a loss in productivity per employee. Information exchange and management control using hypercommunications can allow producers to manage larger operations than previously thought possible until computer networks allowed unified control of Front Office and Back Office operations over distances that had been previously technological infeasible.

One of the main indicators of needs is the number of employees per firm. Some specific effects of firm size on hypercommunication costs are covered in Chapter 7. Of course, size is related to horizontal and vertical integration as was covered in 6.3.4. However, hypercommunications is important for several kinds of firms for size-related issues as shown in Table 6-17.

Table 6-17 summarizes hypercommunication needs based on firm size, sector size, or marketing area. Firms such as Dole and Del Monte use hypercommunications to control agricultural product form through channels they own over time. They also are most likely to be multinational operations with enormous overseas operations, a large number of divisions, and tens of thousands of employees. However, the needs listed in table 6-17 do not require a multinational size. In fact, that is one of the revolutionary things about information technology and hypercommunications. Technical change is proceeding at such a breakneck pace that costs of many technologies are changing exponentially for the better, even as their prices drop considerably.

Table 6-17: Hypercommunications as an important tactic to achieve goals or fill needs based on firm size or marketing area

Need or goal	Examples	Action
General expansion of marketing footprint	Passive expansion: firm enters new territories, seeks global e-business trade.	Web-site, e-commerce, Extranet with new suppliers
General expansion of sales staff, locations, employees	Active or aggressive expansion: firm hires new employees, builds new locations, plants.	VPN, Intranet, private data networking, CTI
Increase sales per existing customer	Goal to serve existing customers better. Possible special treatment for customer s-groups.	Extranet used to tie larger, existing customers much better, discounts for web site purchases,
Increase in foreign sales or purchases	Desire to serve Mexico, Caribbean, Africa, Asia, Europe	Possibility that some communication may have to be in foreign language. Web sites can be automatically translated.
Foreign language needs	New exporter	International communication alone or with shipper agent
Large firm's desire to implement more knowledge-based, research-oriented, innovative firm.	Biotechnology firm that needs to enter agriculture in addition to medicine.	Research and development, organizational information policy, CIO, CTO.
E-commerce, CTI, state of the art order center	Business needs to consolidate equipment bought at different times, by different people, for different departments into something generally useful.	Hire (and use) the advice of a qualified person responsible for telephones, computers, Internet, the website, etc. RFP the project.
Interact with large number of buyers and sellers on routine, repetitive transactions.	Employees (and customer employees are spending too much time working on details and errors in paper forms, often written in different locations, under different circumstances. If firm does not outsource, it needs to buy, install, train, and use database packages on computers both at home office and elsewhere.	EDI, Internet, Extranet. Make sure database program is compatible with firms you trade with before buying.

For larger international agribusinesses, the Internet and private data networking are already responsible for decreases in the firm's outlay on substitutes such as international and domestic communications costs (including travel, telephone, fax, postal delivery services, and advertising). Hypercommunications provide better management control of far-flung operations and superior customer service for information-savvy large clients. Unit costs for hypercommunications are expected to continue to drop thanks to deregulation, but the quality, capacity, and failure rate of hypercommunications technologies and services differ substantially.

Firms may also purchase new technology (while holding employee numbers constant) in the hopes of becoming more productive. This move is usually rewarding only when adequate time is taken to train staff on new equipment. Typically, in seasonal agribusinesses the slow time of year should be chosen if possible.

Chapter 6 has focused on market boundaries, agribusiness hypercommunication needs, and the units of hypercommunications. Hypercommunications can be inconvenient to buy because of the irregular boundaries among providers (markets with POPs where access is sold) and transport sales are highly dependent on fiber optic infrastructure. However, today's transport will be tomorrow's access (data rate and bandwidth). If the problem with market boundaries is not bad enough, the products are defined in different ways between companies and even inside companies in many cases. Most unique hypercommunications come from characteristics of agriculture which, when taken together, make agribusiness communication needs more diverse than many would imagine by thinking only of farming. This is especially true in Florida. Now, two final topics are covered in the last chapter, Chapter 7. First, "*From whom?*" will agribusinesses buy hypercommunications and "*How much?*" will they cost.

CHAPTER 7
HYPERCOMMUNICATION SUPPLIERS, COSTS, CONCLUSIONS, AND RECOMMENDATIONS

"It's not who you know, it's what you know." Ricoh Corporation slogan, 1999.

"Share the knowledge, continue the conversation." Xerox corporate slogan, 1999.

Chapter 7 concludes this study of agribusiness hypercommunications convergence in Florida. This chapter is meant to help agribusinesses decide "*From whom?*" to buy (section 7.1) and "*How much*?" to pay (section 7.2) for hypercommunications. Only general answers to these two questions are possible because each agribusiness' needs vary. Those two sections are followed by a brief set of recommendations concerning agribusiness hypercommunication strategy in section 7.3. Then, the conclusions that first, convergence is arriving, and second, that agribusinesses must be ready are made in section 7.4.

As both the slogans above suggest the choice of hypercommunications services, technologies, and carriers by an agribusiness are important because the information economy is a knowledge-based economy. Therefore, how an agribusiness chooses to communicate involves more than saving money or reaching a greater number of customers. The hypercommunications strategy chosen by an agribusiness could determine whether it can continue to operate competitively in the new, knowledge-based economy.

This final chapter gives broad guidelines for agribusiness decisions concerning overall strategy and tactics in choosing hypercommunication services. However, as the preceding eight-hundred pages have shown, hypercommunication services, technologies, markets, and carriers are complicated and in a state of constant change. Thus, Chapter 7 cannot offer a simple "one-size-fits-all" hypercommunications strategy for every Florida agribusiness. The needs, locations, budgets, existing CPE, local infrastructure, management attitude towards technological change, entrepreneurial spirit, and desire for growth vary among Florida agribusiness.

7.1 Hypercommunication Suppliers

This section introduces agribusinesses to a variety of hypercommunications suppliers (carriers) in Florida. The product mix sold by a hypercommunications carrier varies according to many factors. First, a carrier offers service in *at least one* of several sub-markets (POTS, enhanced telecommunications, private data networking, and Internet) that were outlined in 4.6 through 4.9. Second, a carrier may have a broad or narrow menu of service bundles *within* each sub-market. For example, in the Internet area, one ISP may offer only two kinds of dial-up accounts, while another ISP sells a full range of services including dial-up, many kinds of dedicated access, VPNs, web design, website promotion, and e-commerce. The third and most important dimension of product mix concerns convergence or carriers who offer service bundles that encompass multiple sub-markets. One firm may offer telephony, enhanced telecommunications, private data networking, and the Internet as separate products, sold by separate divisions, each with different sales representatives, bills, and tech support contacts. Another firm may combine all four offerings into a single product with unified tech support, one salesperson, and one bill.

Since convergence is not yet a complete reality, agribusinesses are left to choose from providers in six categories outlined in this section, each specializing in one-sub market, but often branching into other areas. While most providers have an eventual goal of offering converged hypercommunication products from each sub-market, their abilities to do so currently differ dramatically.

Table 7-1 shows the provider categories to be covered. Sub-section 7.1.1 covers the structure of the hypercommunications supplier market. Then, six kinds of providers (as defined by the pre-convergent marketplace) are covered. For each provider type shown in Table 7-1, a brief description is given, along with a list of the most important firms in that category in Florida.

The services offered by a particular provider also depend on its infrastructure and business strategy regarding convergence. Once a hypercommunications provider decides what POPs it wants, it must decide what mix of services are technically possible and economically profitable for a particular local market, if regulation allows entry. Not all carriers have their own infrastructure, since many are resellers of another firm's network, while others own parts of their own networks while sharing other network elements with other carriers.

Carriers use various technologies to provide access and transport services, as well as to maximize bandwidth available for customer traffic while minimizing the cost of bandwidth purchased from wholesalers. Carrier strategies on how to implement convergence differ. Some carriers find it more profitable to offer separate voice, data networking, Internet, and enhanced telecommunications products. Other carriers feel their future profitability is best assured by converging separate sub-market services into a single hypercommunication service and cutting prices.

Other firms supply hypercommunications services such as web design, consulting, and other facilitating firms, hardware and software makers, etc. Discussions of these other suppliers were included in the appropriate section of Chapter 4. For example, Internet web designers, website promoters, e-commerce programmers, and other related personnel were discussed in section 4.9 on Internet services and technologies.

Table 7-1: Overview of Hypercommunication Suppliers

Sec.	Description	Traditional products	Converging situation
7.1.1	Market structure	Separate firms, separate services: POTS, enhanced telecommunications, private data networking, Internet	Merged companies offering converged access and transport
7.1.2	Telco suppliers		
	ILECs	Local telephone monopolies: POTS. enhanced telecommunications, leased lines	Long-distance, Internet, high-end data networking, SMDS, DSL, ATM
	ALECs	Local telephone competitors: POTS, enhanced telecommunications	Internet, high-end data networking, converged networks, DSL, ATM
	IXCs	Long-distance carriers: enhanced telecommunications, data networking	Local and long-distance POTS, data, Internet, wireless access
7.1.3	Cablecos	Analog and digital cable TV	Internet, telephony, data networking
7.1.4	Internet suppliers		
	ISPs	Web hosting, POP-Internet transport, e-mail, dial-up access	Dedicated access, DSL, VPNs, data networking, converged voice-data
	NSPs	Web hosting, Internet backbone connections	Dedicated access, ATM, SONET, converged voice-data, managed router services
	OSPs	E-mail, online service	DSL, web hosting
7.1.5	Terrestrial mobile wireless		
	Analog Cellular	Cellular telephony, AMPS	Becoming obsolete
	Digital Cellular	Digital cellular telephony	CDPD
	PCS	Digital telephony, paging	Limited wireless Internet
	Wireless Paging	Tone paging, one-way	Enhanced two-way text and voice paging
	SMR	Digital cellular telephony, two-way radio communications	Internet, two-way text and e-mail messaging
	3G	Not available	Faster wireless Internet, data networking, telephony, and e-mail
7.1.6.	Terrestrial fixed wireless		
	2.4 GHz WCS	Two-way Internet, WWAN, WLAN	Internet, voice, data networking
	MMDS	Wireless cable, two-way Internet, SOHO	Improved capacity
	LMDS	Broadband WAN, access	Telephony, video
	DEMS	Broadband access, telephony, WAN, video, Internet	Improved range, capacity
	WLL	Broadband WAN, access, Internet, telephony	Full wireless T-3 (converged) to 155 Mbps
	WLAN	Wireless LAN	Expanded coverage areas
7.1.7	Satellite		
	DBS (GEO)	TV, one-way Internet	Two-way Internet
	MSS	Mobile satellite telephony	Possible data and Internet
	LEO	Paging, GPS, remote monitoring	Two-way data, Internet, Satellite telephony, broadband PCS
	Broadband GSO/LEO	Voice transport, high-latency data	Internet, WAN, converged networks
	MEO	Messaging	Internet, data networking

7.1.1 Hypercommunications Supplier Market Structure

The structure of the hypercommunications market includes the number of services, number of firms, and competitiveness of providers within and between sub-markets. The hypercommunications environment is rapidly changing. Definitions of the entire hypercommunications market, sub-markets, and services are altered almost daily due to mergers, spin-offs, new technologies, and new entrants. Therefore, the structure of the hypercommunications industry will be shaped differently in 2001 than it is in 2000.

The scientific and technical aspects of the hypercommunications industry were covered in Chapters 2, 3, and 4 to explain the inevitability of some structural changes in hypercommunication suppliers. Geographic and regulatory aspects of market definitions (which also affect structure) were mentioned in Chapter 5. Taken together, the material presented earlier suggests several changes are in store for the structure of the Sunshine State's hypercommunications market.

Recall that the fifth convergence was competitive convergence[1]. Under this convergence, the market moves more towards along a continuum between monopoly and perfect competition. If firms merge or technically converge, then the number of firms is being reduced, which tends to create movement towards the monopoly end of the continuum. In hypercommunications, potentially pro-competitive influences (deregulation, elimination of regulatory monopolies, IPOs, spin-offs, interconnection, etc.) are hard to separate from potentially anti-competitive influences (existing regulation, technical convergence, mergers, re-regulation, non-uniform taxation across sub-industries).

The field of industrial economics teaches that the structure of the market, market conduct, and market performance are not synonyms. An oligopolistic or monopolistically competitive market[2] can be as efficient as a purely competitive depending on conduct of firms. Convergence tends to guarantee competition among technologies and services. However, market boundaries (6.1), mergers, and some forms of bundling (6.2) may be anti-competitive.

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[1] Several forms of hypercommunications convergence are covered in 4.1.

Hypercommunications market power is obtained in many ways. Sources of market power include: having better information than customers or competitors, legal monopolies, patents, or licenses, the number of firms, the number and structure of sub-markets, and the ability to price discriminate. Some sub-industry players are merging, acquiring, and forming strategic partnerships with others to yield more diversified operations. Often such moves occur because one firm does not an array of technologies in place to offer a full range of services.

Figure 7-1 illustrates how the separate provider categories summarized in 7.1.2 through 7.1.7 are converging towards a single category: that of hypercommunications carrier. As time passes, convergence will change the definition of the market. The current state of the hypercommunications market is a number of disjointed and (until very recently) separately owned sub-industries. These include traditional telephony, enhanced telecommunications, private data networking, Internet access, mobile wireless telephony, and satellite communications. As convergence begins, the lines are blurring among these sub-industries.

The tendency has been for some sub-industries to be monopolies such as the incumbent telephone company (ILEC), electric utility, newspaper, telegraph company, and cable TV provider. Sub-industries composed of former monopolies are used to being regulated and not to competition. However, other sub-industries such as software, hardware, fixed wireless, and Internet access have remained regulation-free and almost tax-free as well. These "new" hypercommunication sub-industries are used to competition but not regulation. It is important for agribusinesses to realize that there is a greater choice of carriers than might me realized, with still more coming.

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[2] This idea precedes Chamberlain (1936) in the works of John Elliott Cairnes (1823-75). Cairnes was in the John Stuart Mill (1806-73) school (see Spiegel, 1991) but Mill based his ideas on Longfield's (1802-84).

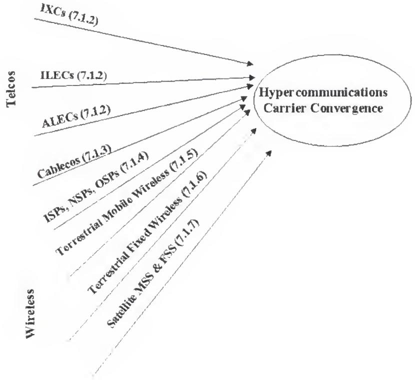
IXCs (7.1.2)
Telcos
ILECs (7.1.2)
ALECs (7.1.2)
Hypercommunications Carrier Convergence
Cablecos (7.1.3)
ISPs, NSPs, OSPs (7.1.4)
Terrestrial Mobile Wireless (7.1.5)
Terrestrial Fixed Wireless (7.1.6)
Satellite MSS & FSS (7.1.7)
Wireless

Figure 7-1: Convergence of carrier categories

However, while separate carrier categories will converge into one market of competing technologies as suggested in Figure 7-1, the present market is organized according to the categories in Table 7-1. By looking at providers in separate categories one at a time, it will be easier for agribusiness managers to answer the question of "*From whom?*" they can buy and ultimately should buy hypercommunications.

7.1.2 The Telco Suppliers: ILECs, ALECs, and IXCs

The first group of hypercommunication suppliers is the telecommunications carriers, which include both local and long-distance telephone companies. This group includes ILECs (Incumbent Local Exchange Carriers), ALECs (Alternative Local Exchange Carriers), and IXCs

(Interexchange Carriers). Most telco carriers depend on wireline technologies and infrastructures. Recall from 4.6 that traditional local telephony is a bundle of services including local loop, signaling, intra-exchange local and intra-LATA local calls. Since the wireline telephone access infrastructure (the last mile of the local loop) is owned by the ILEC, the ILECs remain powerful in spite of deregulation.[3] Since the breakup of AT&T, long-distance calls (which include intra-LATA long distance calls, inter-LATA long distance calls, and international calls) are carried by IXCs (Inter Exchange Carriers). ALECs have entered the local and long-distance field and are joined (in some areas) by cablecos, electricos, ISPs, and NSPs.

Table 7-2 and Table 7-3 show details of ILEC operations in Florida. Florida has ten ILECs, or providers of local telephone service, enhanced telecommunication services, and private data networking products. ILEC infrastructure and technologies were introduced previously in Chapter 3 and Chapter 4. The FCC and the FPSC regulate ILEC pricing.[4]

BellSouth, Verizon (GTE-Bell Atlantic), and Sprint represent all but a small percentage of access lines as Tables 7-2 and 7-3 show. These three ILECs (classified as non-rural carriers by the FCC) are responsible for most urban and rural local loops. In other areas, a small independent company or rural telephone cooperative is the ILEC.

Table 7-3 shows that ILECs represent just over fifty percent of all telephone prefix (NPA) assignments in Florida, with the balance represented by wireline and wireless ALECs and mobile telephone providers. While small ILECs showed a higher growth rate in access lines from 1998 to 1999, the three main ILECs (BellSouth, Sprint, and Verizon) represented over 97% of demand for new access lines statewide.

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[3] Figure 5-6 (in 5.3.3) showed the service areas of Florida ILECs, while Figure 4-38 (in 4.6.1) showed LATA and area code boundaries.

[4] Chapter 5 provides details.

Table 7-2: LATAs and area codes served, total access lines, for Florida ILECs

ILEC	LATAs served (any portion)	Area codes served	Access lines, 1998	Access lines, 1999
Alltel Florida	Jacksonville, Daytona, Gainesville	904, 352	78,106	82,719
BellSouth	All but Tampa, Ft. Myers	All but 727, 813, 863, 941	6,223,751	6,481,986
Frontier Communications (Global Crossing)	Pensacola	850	4,142	4,266
GT Com (Gulf, St. Joseph, Florala)	Panama City, Tallahassee	850	43,441	46,415
GTE Florida (Verizon-Bell Atlantic-GTE)	Tampa	813, 727, 863, 941	2,268,455	2,368,938
Indiantown Telephone System	Southeast	561	3,421	3,537
N.E. Florida Telephone Company	Jacksonville	904	8,022	8,592
Sprint (United, Central)	Ft. Myers, Orlando, Gainesville, Daytona, Tallahassee	321, 352, 407, 850, 863, 904, 941	1,930,720	2,048,042
TDS Telecom (Quincy Telephone)	Tallahassee	850	13,249	13,270
Vista-United (Disney)	Orlando	407, 321	13,513	15,236

Source: FPSC, *Annual Report, 1999* (2000).

Table 7-3: Various measures of Florida ILEC size and growth, 1999

ILEC	Share, access lines	Share, prefixes	Share of access line growth	98-99 access line growth rate
Alltel Florida	0.75 %	35 (0.59%)	0.95%	5.9 %
BellSouth	58.54 %	1683 (28.33%)	52.92%	4.1 %
Frontier Communications (Global Crossing)	0.04 %	3 (0.05%)	0.39%	3.0 %
GT Com (Gulf. St. Joseph, and Florala)	0.42 %	26 (0.87%)	0.61%	6.8 %
GTE (Verizon-Bell Atlantic-GTE)	21.39 %	691 (11.63)	20.59%	4.2 %
Indiantown Telephone System	0.03 %	1 (0.02%)	0.02%	3.4 %
Northeast Florida Telephone Company	0.08 %	3 (0.05%)	0.12%	7.1 %
Sprint (United, Central)	18.50 %	539 (9.07%)	24.04%	6.0 %
TDS Telecom (Quincy Telephone)	0.12 %	4 (0.07%)	0.00%	0.2 %
Vista-United (Disney)	0.14 %	8 (0.13)%	0.35%	12.8 %

Source: FPSC, *Annual Report, 1999* (2000).

However, a new group of telcos has entered the market with a decidedly pro-competitive, anti-monopoly corporate culture and price competitive attitude. Most of the 425 ALECs in Florida [FPSC, August 9, 2000] primarily serve business customers, typically businesses needing 23 or 24 ALEs (the voice capacity of a T-1). ALECs (also called CLECs nationally, for Competitive Local Exchange Carriers) are often accused of "skimming" the best customers from the monopoly ILEC in a particular area, leaving the ILEC (a COLR) forced to serve high-cost and rural customers. Some ALECs specialize in serving the requirements of particular industries or certain geographic areas.

Table 7-4 lists twenty of the largest ALECs in Florida, ranked by a combination of ALE weighting and NNX assignments. The subjective ranking is based on FCC and FPSC data, and sketchy proprietary market share data. Under Florida law, ALECs fall into several classes depending on the FPSC certificates they hold. FPSC certificates include AAVs (Alternative Access Vendors), STS (Shared Tenant Service), FBs (Facilities Based carriers), MLDAs (Multi-Location Discount Aggregators), resellers, and SR (Switchless Rebillers). Since each ALEC is free to choose its markets, there is no guarantee that ALECs listed will be able to serve a particular agribusiness' location.

FBs are carriers that own (or expect to own) and operate switches and transport facilities in Florida. Facilities based carriers may have their own exclusive POPs (switches) and their own transport networks or they may share an interest in such facilities with other entities. However, most wireline ALECs resell local loop capacity of ILECs and do not bypass the local loop. MLDAs contract special multi-location volume discounts on circuits with unaffiliated carriers that the MLDA then resells to its customers. Resellers have switching facilities in Florida, but lease transport and access facilities from other carriers and resell them as lines or trunks to their own customers. SBs are firms that have no switches or facilities in Florida but are able to aggregate traffic to obtain discounts from carriers. An SB bills its customers a rate above its discount, but below the rate a customer would pay without the SB.

Table 7-4: Twenty leading Florida ALECs, ranked by ALE and NPX assignment weights.

Rank	Firm (recent mergers and acquisitions)	ALE weighting, (FPSC certificate codes)	Comments
1	AT&T Local (TGC, TCI, MediaOne)	157 (AAV, FB)	AT&T owns a variety of cable TV and wireless access providers
2	Intermedia (Digex)	93 (AAV, FB, STS)	Sprint has just purchased this firm along with its Internet subsidiary Digex.
3	U.S. LEC	88 (reseller)	Aggressive pricing.
4	MCI WorldCom	85 (AAV, ALEC, FB, STS)	Major national player.
5	ITC Deltacom	62 (reseller)	All LATAs.
6	E.spire (Cybergate)	51	Cybergate, a Florida ISP was purchased by E-spire.
7	Time Warner (AOL)	44 (AAV, STS, SR)	Cable provider.
8	XO (Concentric, Nextlink)	40 (reseller)	Wireless provider merged with NSP-ALEC.
9	Broadband Investor's Group (Global NAPs, WorldNET)	35 (FB)	cnaps.com
10	mpower (MGC)	33 (FB)	SDSL converged provider
11	IDS Telecom	30 (FB, SR)	Possible takeover target.
12	Elantic (Florida Digital Network)	29 (FB)	Merger of three firms.
13	Alltel	27	ILEC in NE Florida, ALEC and wireless carrier elsewhere
14	Winstar	24(AAV, MLDA)	Fixed wireless provider.
15	Hyperion (Adelphia)	24 (AAV, FB, SR)	Cable TV company.
16	KMC Telco (Tier 3)	20 (FB, AAV, SR)	Possible takeover target.
17	Level 3	19 (FB, reseller)	National Internet NSP.
18	2nd Century	17 (FB, reseller)	Converged provider.
19	PAETEC	15 (reseller)	Orlando and Southeast LATAs only.
20	Sprint Metro	13 (FB)	ILEC in certain areas, ALEC in others.

The first two categories (AAVs and STSs) can apply to ALECs and/or IXCs. The distinction is based on the combination of special FPSC certificates held by the carrier. Table 7-5 shows what services can be provided according to the FPSC certificate type. As Table 7-4 showed, some ALECs hold several certificates, while others are ALECs only.

Table 7-4: Services permitted according to FPSC certificate type

Type	Local switched	Local private line	Inter-LATA private line	Intra-LATA private line	Intra-LATA switched toll	Inter-LATA switched toll	EAS & ECS switched	EAS & ECS private line
ILEC	Yes	Yes	No	Yes	Yes	No	Yes	Yes
ALEC	Yes	Yes	No	Yes	Yes	No	Yes	Yes
STS	Yes	No	No	No	No	No	Yes	No
AAV	No	Yes	Yes	Yes	No	No	No	Yes
IXC	No	No	Yes	Yes	Yes	Yes	Yes[5]	Yes

ALECs, like ILECs, are allowed to provide local switched, local private line, intra-LATA private line, intra-LATA switched, and EAS-ECS switched and private line telephony and enhanced telecommunications services. AAVs may not provide local switched services such as basic telephony or ISDN-BRI, but are able to essentially duplicate local service by offering local private line service to an unaffiliated entity, which then offers switched POTS. A telecommunications provider who enters an agreement (often exclusive) with a landlord to provide common switching or billing arrangement to all tenants provides STS to tenants of office buildings, office parks, or apartment buildings.

Recent FCC data suggest that ALECs have yet to gain significant market share in Florida. At the end of 1999, ALECs served fewer than 6 percent of end-user lines in Florida, meaning that ILECs commanded a 94 percent market share [FCC, CCB, *Trends in Telephone Service*, March 2000, Table 4]. Those totals represent a dramatic increase from a year before when less than two percent of ILEC lines were provided to ALECs for resale. The increase was made possible by an increase in the number of ILEC lines with ALEC collocation agreements. In June 1999, 80 percent of BellSouth lines, 21 percent of Verizon (GTE-BellAtlantic) lines, and 27 percent of Sprint lines could interconnect to ALECs. Thus, the number of lines over which competitors could offer service had doubled in one year [FCC, CCB, *Local Telephone Competition Report*, August 31, 2000]

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[5] While EAS (Extended Area Service) and ECS (Electronic Cross-connect System) switched services are local, IXCs may transport calls between exchanges.

Table 7-5 lists the top five IXCs in Florida by market share of the residential market in Florida. Increasingly, many IXCs have diversified into local telephony, cable TV and Internet, wireless access, mobile wireless, and other lines of business.

Table 7-5: Top five Florida IXCs.

Rank	Firm	Market share, residential toll (percent)	1999 revenues
1	AT&T	63.1	$62.4 billion
2	MCI Worldcom	18.1	$37.1 billion
3	Sprint	5.9	$19.9 billion
4	TeleGlobe (Excel)	3.3	
5	Others	9.6	

Sources: FCC, CCB, *Local Telephone Competition Report*, August 31, 2000

For every agribusiness location, telephone and enhanced telecommunication services can be purchased from the ILEC that serves that area or from ALECs and IXCs. Most telcos offer data networking and Internet service as well. However, the telcos are not the only wireline choice for hypercommunication services available.

7.1.3 Cablecos and Electricos: Cable TV and Electric Utility Suppliers

Cable television providers in Florida have an alternative wireline access infrastructure to that offered by the wireline telcos. The cable infrastructure can be more inexpensively upgraded to fiber access to provide high-speed hypercommunication services and technologies as was discussed in 4.3.3. However, some question whether cable-based data services and Internet have the privacy and reliability to be business-class providers. Nonetheless, most Florida cable providers are busy rolling out an infrastructure capable of offering converged services. Some electric utilities and even the Florida East Coast Railroad also offer communications wireline access and other hypercommunication services.

Table 7-6 shows the largest Florida cablecos of 280 total providers, their estimated pass rate (maximum number of homes that could be served), and total subscribers.

Table 7-6: Florida cablecos with cable modem deployments.

Firm (mergers)	Florida basic cable TV subscribers	National cable TV subscribers (Internet)	Areas served (cable modem deployment in bold)
Statewide	4,737,987		
Time Warner	1,349,000	13,000,000	UI Brevard, Calhoun Cty, Citrus Cty, UI Columbia, Lee, Hernando, **Pinellas**, **Orange**, Pasco, Osceola, Sumter, Seminole, Volusia, Citrus, **Tampa** (Roadrunner)
AT&T Cable (MediaOne, TCI)	665,000	11,400,000 (1,000,000)	Baker Cty, **Broward** sub, Collier Cty, Dade sub, **Duval**, some areas of **Miami-Dade, Ft. Myers** (Roadrunner)
Adelphia (Hyperion)	266,000	5,500,000	Florida City, **UI Dade**, **UI Palm Beach**, Homestead, **West Palm Beach**, St. Lucie Cty
Comcast (Storer, Jones)	NA	5,670,000 (260,000)	Ft. Lauderdale, UI Broward, Charlotte Cty, Tallahassee, **Panama City**, Lake Cty, **Sarasota**, **Celebration,** Hardee Cty, Polk, Highlands, UI Bay, UI Osceola
Coxcom	246,000	5,752,000 (320,000)	**Gainesville**, Okaloosa Cty., Walton Cty (Excite @Home)
Verizon Americast (GTE Media)	NA	102,000	**Clearwater, Pinellas suburbs** (Worldwind Internet)
Rifkin (Charter)	64,000	460,000	**Miami Beach, suburbs**
Mediacom SE	56,000	755,000 (3,600)	Franklin, Gulf, Holmes, Gadsden, Santa Rosa, Washington, **Milton, Gulf Breeze**
MindSpring	NA	NA	**Panama City**
Advanced Cable	46,000	46,000	**Coral Springs, Weston**
Galaxy Telecom	30,000	240,000	Clay Cty, UI Lake, UI Putnam, UI Marion, UI Sumter
Communi-Comm	NA	NA	**High Springs, Alachua** (Netcommander Internet)

Sources: CATV.org (2000); Cablevision, *Database*, January 20, 2000.

By June 2000, cable high-speed Internet subscribers in Florida among the eight active providers stood at 127,000 households and small businesses. Where available, the table provides information about national and Florida subscribers to basic cable to give an idea of the size of the firm. When available, the number of Internet subscribers nationally is found in parentheses after the national basic TV subscriber figure. Agribusinesses will have to contact their local cable company directly to find out what services (Internet, telephone, data networking) are available in their area and if businesses can even get service.

Locations depend on the franchising authority so that cities, counties (abbreviated as Cty.), and un-incorporated areas (abbreviated as UI) are listed. Importantly, cable services may be offered over a geographically limited area within the areas served. More discussion about cable may be found in 4.3.3. Many of the firms listed also offer telephone and private data networking services. These carriers include Time Warner, AT&T Cable, Adelphia, and Cox. Not all firms offer services to businesses.

Dark fiber providers such as electric utilities also offer communications services in some areas. Table 7-7 summarizes the services offered by many publicly-held electric utilities, a few municipal utilities, along with all fifteen of Florida's rural electric co-operatives. Since circumstances are changing quickly, the website listed for each electrico is shown, so the most recent information may be consulted.

Cableco and electricos often serve different ends of the market. Many cablecos offer services aimed primarily at residential customers though some offer small business services. However, they are often unavailable in rural or sparsely settled areas. Electric companies are able to offer high-capacity "dark fiber" connections to businesses located in metro areas. However, many electricos offer wholesale services for hypercommunication carriers alone, rather than retail service to smaller businesses. Rural electric co-ops currently offer little more than dial-up Internet, though some have ambitious plans to offer an array of voice and data services in the near future.

Table 7-7: Electric utilities in Florida by availability of Internet and other services

Utility	City	Website	Internet provider? (backbone)
Florida Power & Light (Entergy)	Miami	www.fpl.com, www.fplfibernet.com	YES: High-speed (DS-3 to OC-192) transport connections (Genuity)
Florida Power Corporation (Florida Progress Corp., now part of CP&L Energy)	St. Petersburg	www.fpc.com, www.progresstelecom.com	YES: Progresstelecom subsidiary is an ALEC and AAV. (Genuity)
Tampa Electric Company (TECO)	Tampa	www.teco.net	YES: Metrolink subsidiary provides high-capacity bandwidth such as SONET. (Sprint)
Gulf Power	Pensacola	www.southernco.com, www.southernlinc.com	YES: Mobile wireless data, Internet, and voice
JEA (City of Jacksonville)	Jacksonville	www.jea.com	NO
Kissimmee Utility Authority	Kissimmee	www.kua.com, www.kua.net	YES: Internet access from dial-up to T-3s (Sprint, MCI-WorldCom)
Gainesville Regional Utilities	Gainesville	www.gru.com, www.gru.net	YES: high-speed access and transport, dial-up Internet access (Sprint)
Rural Electric Co-ops (Territory shown in Figure 7-2)			
Seminole EC	Tampa	www.seminole-electric.com	NO
1 Escambia River EC	Jay	www.erec.net	YES (AT&T)
2 Choctawhatchee EC	DeFuniak Springs	www.chelco.com	www.tri-c.com (Genesis)
3 West Florida EC	Graceville	www.wfeca.net	YES (AT&T), satellite TV
4 Gulf Coast EC	Wewahitchka	www.gtec.com	NO
5 Talquin EC	Quincy	www.talquinelectric.com	NO
6 Tri-County EC	Madison	www.tcec.com	NO
7 Suwannee Valley EC	Live Oak	www.suwanneevalleyemc.com	www.suwanneevalley.net (alter.net)
8 Okefenokee EC	Nahunta, GA	www.oremc.com	NO
9 Clay EC	Keystone Hts.	www.clayelectric.com	NO
10 Central Florida EC	Chiefland	www.cfec.com	www.tri-c.com (Genesis)
11 Sumter EC	Sumterville	www.sumter-electric.com	NO
12 Withlacoochee EC	Dade City	www.wrec.net	NO
13 Peace River EC	Wauchula	www.preco.org	NO
14 Glades EC	Moore Haven	www.gladesec.com	NO
15 Lee County EC	Fort Myers	www.lcec.net	www.iline.com (Sprint)
16 Florida Keys EC	Tavernier	www.fkec.com	NO

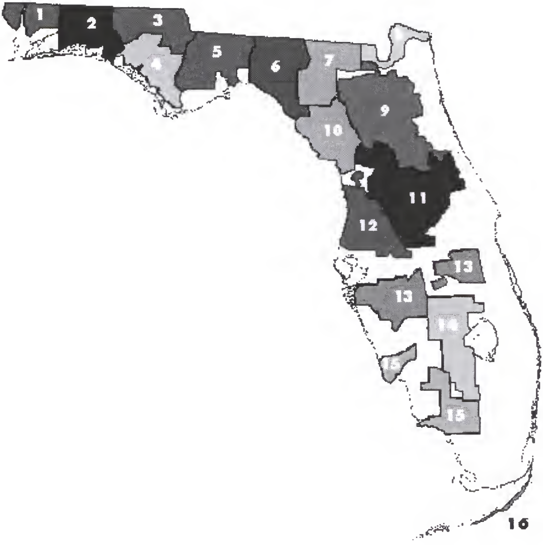

Figure 7-2: Rural electric cooperative territories as numbered in Table 7-7.

7.1.4 Internet Providers: NSPs, ISPs, and OSPs

Recall from Figure 4-56 in 4.9.1 that there are several physical stages in the QOS reference model needed to connect an agribusiness to the Internet. In the first stage (access stage), a connection is established from the agribusiness to an Internet provider's POP. A telco circuit (such as a fractional T-1) is leased by the agribusiness for that purpose. In the next stage (transport stage), a backbone connection from the POP to the Internet backbone is required. The

ISP charge for "Internet access" covers this second stage, which is really a transport connection. With most forms of wireline Internet, the agribusiness pays two bills. The agribusiness pays one bill (for the special line from the agribusiness to an Internet company's POP) to an ILEC or ALEC to cover the access stage. A second bill is paid to an Internet provider to cover the transport stage. Wireless ISP customers (along with AAV and bypass wireline customers) avoid the telco access circuit charge.

Since many Internet providers are not Tier 1 providers (NSPs, Network Service Providers), a third, intermediate stage occurs for smaller ISPs who hand off traffic to an NSP with a backbone connection. Internet Service Providers (ISPs) and their cousins Online Service Providers (OSPs) connect to the Internet backbone through circuits connecting their local POPs and the Internet. Some ISPs and all NSPs sell such wholesale connections to smaller ISPs as well as to retail customers. ISPs, in turn, divide capacity among Internet and private data networking (VPN, frame relay, and other) customers. OSPs divide their capacity among consumer and small business customers. Finally, NSPs divide their capacity among ISPs, OSPs, and large business clients.

The Florida ISP market, like the national one, is in transition. In addition to consolidation among large national and international providers, there are many new small national and regional players than there were a year ago [Boardwatch Magazine, *Directory of Internet Service Providers*, 2000]. However, while most ISPs that served Florida were based in Florida in 1995, by 2000, due to mergers and consolidation, that was no longer the case. Because of deregulation and interconnection, an ISP located in anywhere could sell local dial-up access in Miami, Florida. Table 7-8 demonstrates the concentration of ISPs by area code in Florida. Increasingly, independent small, local ISPs are subject to takeovers and mergers. However, there has been a jump in national and regional ISPs due to consolidation.

Table 7-8: ISPs serving at least part of Florida area codes, 2000.

Area Code (main city or county)	National ISPs	Regional ISPs	Local ISPs
305 (Miami)	1256	141	44
321 (Melbourne, Orlando overlay)	254	0	0
352 (Gainesville-Ocala)	831	109	30
407 (Orlando)	1177	146	43
561 (West Palm Beach)	857	112	15
727 (Pasco)	646	88	25
786 (Miami-Dade overlay)	440	55	0
813 (Tampa)	687	95	12
850 (Panhandle)	734	81	25
863 (Polk, Highlands, S. central Florida)	254	0	0
904 (Jacksonville-Daytona)	758	91	19
941 (Ft. Myers-Sarasota)	596	99	26
954 (Broward)	745	104	18

Source: Boardwatch Magazine, *Directory of Internet Service Providers*, 2000]

There are so many ISPs it is hard to identify the best in an area. Table 7-9 gives a few of Florida's largest ISPs, or agribusinesses may want to consult the Boardwatch site IspWorld.com.

Table 7-9: Top ISPs in Florida, 2000

ISP	National subscribers	Backbone
AT&T WorldNet	2,200,000	att.net
IBM Net, IBM Net Access 800	NA	prserv.net, att.net
Bellsouth.net	788,000	alter.net (UUnet), cw.net
Concentric (XO)	250,000	concentric.net
Earthlink-Mindspring (Sprint)	4,300,000	att.net, Sprint, Level3
CyberGate (E.spire)	NA	Sprintlink, bctel.net
MSN	3,500,000	msft.net
Gateway.net	1,000,000	alter.net (UUnet)
UUnet (MCI, Digex)	360,000	alter.net, (UUnet) ans.net(digex.net)
FreeInternet.com	1,500,000	bbnplanet.net (Genuity)
PSI.net	NA	psi.net
Net Zero	3,800,000	bbnplanet.net (Genuity)
GTE.net (Verizon, Genuity)	756,000	bbnplanet.net (Genuity)
Global Crossing (Frontier)	NA	glbx.net
Atlantic.net	NA	Sprintlink
FDT (Florida Digital Turnpike)	NA	Sprintlink, gru.net
Verio	NA	verio.net
MediaOne (RoadRunner; AT&T)	1,000,000	att.net
Level 3	NA	level3.net
Exodus	NA	exodus.net

Source: Fusco, 2000; Bawany, 2000, Boardwatch ISP Directory, 2000.

Online Service Providers (OSPs) are responsible for most residential and a sizable amount of small business narrowband modem traffic across the PSTN. America Online (AOL), Prodigy, and CompuServe are the big three, but new launches into the category include Juno and WebTV. The main OSPs in Florida are shown in Table 7-10.

Table 7-10: OSPs in Florida.

Firm	National subscribers	Main backbone provider(s)
AOL (America Online)	20,300,000	atdn.net
Prodigy	2,200,000	Sprintlink
CompuServe (now part of AOL)	1,500,000	alter.net, wcom.net
Juno	3,700,000	exodus.net
WebTV	1,100,000	Sprintlink

Source: Fusco, 2000.

Table 7-11 lists Tier 1 Internet carriers (NSPs) along with their major Florida hubs and maximum capacities. Many NSPs are also ALECs who offer a full range of voice and data services. Some NSPs sell only wholesale connections to other ISPs and NSPs, while others offer a full-range of Internet connectivity down to small business dial-up. Many NSPs offer converged communication products such as telephony and enhanced telecommunications in addition to data networking and Internet.

For example, voice over IP services may be offered over an NSP backbone at low rates. However, since such calls are packetized, digital transmissions they sound worse than PSTN calls under current technology. The issue of voice over IP is covered in more detail in 4.5.4 and 4.9.7. However, such backbone providers tend to be located in urban parts of Florida.

Table 7-11: NSPs (backbone providers) with major Florida hubs.

NSP	Florida hubs (connection)
AT&T	Orlando, Tampa, Miami (OC-48); Ft. Lauderdale, Ojus (N. Miami); W. Palm Beach, Jacksonville (OC-3)
Broadwing (Gemini2000.net)	Miami (OC-12)
Cable & Wireless	Miami (OC-48)
CAIS	Miami, Tampa, Orlando, Jacksonville (all OC-3)
Concentric (XO)	Orlando (T-3)
Epoch.net	Miami, Orlando, Tampa (all T-3)
E.spire	Miami, Ft. Lauderdale, Tampa, Orlando, Jacksonville (all OC-3)
Excite@home	Miami, Tampa, Jacksonville (all OC-48)
Genuity (GTE-Verizon, bbnplanet.net)	Miami and Tampa (OC-12); Jacksonville, Orlando (OC-3)
Global Center (Frontier)	Tampa, Miami, Jacksonville (OC-48)
ICG	Miami (T-3)
Infonet	Ft. Lauderdale, Jacksonville, Orlando, West Palm Beach, Miami, Tampa (all OC-3)
Intermedia (Digex)	Tampa, Orlando, Miami (all OC-3)
Multacom (NetSol, multa.net)	Miami, Tampa (OC-3)
NetRail	Miami and Jacksonville (OC-12); Orlando and Tampa (OC-3)
PSINet	Tampa, Orlando, Miami (OC-96)
Qwest	Pensacola, Lake City, Tallahassee, Jacksonville, Gainesville, Ft. Lauderdale, Miami, Daytona Beach (all OC-192)
Saavis	Tampa, Orlando, Jacksonville, Miami (all OC-3)
ServInt	Miami (OC-48)
Splitrock/McLeod	Miami, Tampa, Orlando (all OC-3)
Sprint	Orlando (OC-3)
Teleglobe	Orlando and Miami (OC-3)
Telia (AGIS)	Miami, Fort Lauderdale, West Palm Beach, Tampa, Tallahassee, Orlando, Jacksonville, Ocala (all OC-3)
UUnet (MCI WorldCom)	Jacksonville, Orlando, Tampa, Miami (all OC-12)
Verio	Miami, Tampa, Orlando (all OC-3); Boca Raton (T-3)
Vnet	Miami (T-3)
Williams	Ft. Myers, Miami, West Palm Beach, Melbourne, Daytona, Jacksonville, Tampa, Tallahassee (all OC-192)
Winstar	Tampa (OC-12); Jacksonville, Orlando, Miami, (OC-3)

Source: *Directory of Internet Service Providers*, Boardwatch Magazine, 2000.

7.1.5 Mobile Terrestrial Wireless Providers

Wireless communication does not require a wireline infrastructure and, therefore, offers flexibility to agribusinesses seeking to communicate from mobile or fixed locations. The FCC estimates that in 1999 at least two wireless providers covered 66 of Florida's 67 counties. Also in 1999, with the exception of a few interior counties (such as Okeechobee and Highlands) along with the panhandle other counties had at least six providers [FCC 00-289, 2000, p.8]

As Table 4-10 in 4.4.2 showed, most mobile terrestrial wireless technologies offer lower data rates than wireline dial-up connections to agribusinesses interested in mobile Internet or data networking. With the advent of new 3G (Third Generation) mobile wireless technologies (such as GSM 1900, W-CDMA, CDMA, and E-TDMA shown in Figure 4-29), the flexibility and capacity of mobile communications are expected to grow. However, most areas of Florida do not have access to 3G mobile services although providers are racing to deploy 3G towers.

Table 7-12 lists terrestrial mobile wireless providers for Florida. According to the FCC, over 5.1 millions mobile telephone subscribers (0.34 subscribers per capita) existed in Florida at the end of 1999 [FCC, IAB, CCB, March 2000, Table 5]. Specialized websites (such as www.wirelessadvisor.com) exist to automate price comparisons and provide agribusinesses with more detail than Table 7-12 does about mobile terrestrial wireless providers.

Mobile terrestrial wireless services also include paging providers (now called wireless messaging firms such as Arch (formerly Mobilecom). Two-way wireless messaging providers are not covered in Table 7-12. However, as reported in 4.7.6 some systems are far more sophisticated than the beeper of yesteryear. The most sophisticated wireless messaging devices can send, receive, and store two-way text and voice messages. These units will be more useful in the near future if the two-way wireless messaging coverage areas (shown in Figure 6-3) become deployed before those of the 3G mobile telephone providers. Already many 2G PCS telephone providers offer text, e-mail, and wireless Internet capabilities in addition to telephony.

Table 7-12: Leading mobile terrestrial wireless carriers in Florida.

Carrier	Technology	MSA/RSA
Cellular (digital and analog)		
Alltel	PCS available	Tampa-St. Petersburg, Lakeland-Winter Haven, Melbourne-Titusville-Palm Bay, Daytona Beach, Ft. Myers, Sarasota, Pensacola, Tallahassee, Gainesville, Bradenton, Ocala, Fort Walton Beach, Panama City, Counties: Collier, Glades, Hardee, Citrus, Putnam, Dixie, Hamilton, Jefferson, Calhoun, Walton, Monroe
AT&T Wireless	70% digital, PCS available	Miami-Ft. Lauderdale-Hollywood, Tampa-St. Petersburg, Jacksonville, Orlando, West Palm Beach-Boca Raton, Lakeland-Winter Haven, Melbourne-Titusville-Palm Bay, Daytona Beach, Sarasota, Ft. Pierce, Bradenton, Ocala, Counties: Glades, Citrus, Putnam
SBC-BellSouth (Alloy LLC)	Some PCS (GSM, TDMA)	Miami-Ft. Lauderdale-Hollywood, Jacksonville, Orlando, West Palm Beach-Boca Raton, Melbourne-Titusville-Palm Bay, Daytona Beach, Counties: Collier, Glades, Citrus, Putnam, Monroe
Price[6]	No PCS	Panama City
US Cellular	No PCS	Tallahassee, Gainesville, Ft. Pierce, Counties: Putnam, Dixie, Jefferson, Calhoun, Walton
Broadband PCS		
Powertel	PCS	Tallahassee, Jacksonville, Gainesville
Verizon	Varies by area	Statewide. Merger of GTE Mobile, Vodafone, AirTouch, PrimeCo, and Bell Atlantic Wireless
Sprint PCS	GSM	Ft. Myers, Miami, West Palm, Broward, Tallahassee, Gainesville, Tampa, Daytona Beach, Lakeland, Sarasota, Brevard
Voicestream	GSM	Daytona Beach, Tampa, Orlando, Miami, West Palm, Ft. Lauderdale, Brevard, Sarasota
SMR (iDEN)		
Nextel	iDEN	Statewide, except panhandle

Sources: FCC 00-289, 2000, pp. G-1-G-25; wirelessadvisor.com

Most systems available in Florida have transitioned from 1G analog AMPS to 2G systems. However, deployment of 3G systems by SBC-BellSouth Mobility is underway in South Florida. It is unknown how long it will take for mobile 3G to become more commonly offered, but Sprint PCS, Voicestream, Nextel, and Verizon are known to be preparing service introductions as soon as 2001 in Florida.

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[6] Verizon has announced an intention to acquire Price.

7.1.6 Terrestrial Fixed Wireless Providers

Table 7-13 lists major fixed wireless carriers in Florida offering upperband service. If located in a coverage area, agribusinesses can bypass the wireline local loop to obtain a variety of communication services, typically at a low rate, from these carriers.

Table 7-13: Leading upperband terrestrial fixed wireless carriers in Florida, licensed spectrum.

Carrier	Technology	Area or counties
MCI Wireless One Investments CAI	MMDS, 26 GHz	Not rolled out in Florida.
Sprint Broadband Direct	MMDS, 26 GHz	Not rolled out in Florida.
XO (Nextlink)	LMDS, 28 GHz	Status unknown after XO merger.
Winstar	WLL, 39 GHz	Jacksonville, Orlando, Tampa-St. Petersburg-Clearwater, Miami-Ft. Lauderdale, Ft. Myers-Cape Coral, Sarasota-Bradenton
ART (Broadstream)	39 GHz	Licensed over most of Florida, rollout upcoming.
Hyperion	LMDS, 39 GHz	Jacksonville
AT&T (Project Angel)	39 GHz	Licensed to cover 60% of Florida land area.
Airwire.net	WLL, 39 GHz	Orlando, Brevard
Teligent	DEMS, 24 GHz	Miami-Dade, West Palm Beach, Orange, Osceola, Hillsborough, Pinellas, Jacksonville

Source: FCC 00-289, company websites.

The providers mentioned in Table 7-13 will be (or are) able to offer up to T-3 wireless capacity at attractive prices, comparable to pricing for wireline T-1s, offering thirty times greater capacity. However, current technology and deployment is limited to STS and center city applications since high frequencies have shorter ranges. Eventually, a cell architecture and improved CPE will extend ranges and reduce interference. Providers listed in Table 7-13 offer voice, data, and Internet services.

More common now in Florida and more useful to agribusiness are lowerband services sharing unlicensed spectrum. Table 7-14 lists fixed wireless providers who operate using spread spectrum technology in the 2.4 GHz or 5.8 GHz (U-NII, Unlicensed National Information Infrastructure) bands. Coverage areas typically range from 20-40 miles from each tower site.

Therefore, the areas served shown in the table vary depending on how many towers a provider constructs.

Table 7-14: Fixed high-speed wireless providers (unlicensed spectrum)

Service	Area of Florida served by wireless	Wireless services	URL
National Providers			
PSINet InterSky	Ft. Myers, Naples, Tampa, Miami	Internet, data networking	www.psi.net
Fuzion	Delray Beach, Boca Raton, Miami, West Palm, Broward, Tampa area	Internet, data networking	www.gofuzion.com
Airdata WIMAN	Tampa, Naples, other areas	All	www.wiman.net
Metricom Ricochet	Miami	Internet	www.metricom.com
Circle.net	Jacksonville, Miami, Tampa	All	www.rocketlauncher.net
Local Providers			
Absolute Networks	Vero Beach area	Internet	www.absolutenet.com
Advanced Digital Information Systems	Pensacola to Ft. Walton Beach (coast)	Internet, voice	www.adisfwb.com
AirLink	Ft. Myers	Internet, data, mobile data	www.goairlink.com
American WirelessWeb	South Florida	Internet	www.directnet1.net
AugLink	St. Augustine area, Duval, Putnam, Flagler	Internet	www.aug.com
ClearAccess Communications	9 counties from St. Petersburg to Naples, expanding to cover 50% of state	All	www.clearaccess.net
Florida Wireless	Hernando County	Internet	www.florida-wireless.com
Gulf Coast Internet	Pensacola	Internet	www.gulf.net
InetUSA (Network Group)	Brevard	Internet	www.inetusa.com
Interatworld	Miami-Dade	Internet	www.interatworld.com
IPQuest (Quest Net)	Sebastian to Key West	Internet	www.ipquest.com
Network Telephone Internet	Palm Beach Cty., Gainesville, Orlando area	All (currently offers wireline VoDSL)	www.networktelephone.net
PDMNet	Indian River, Martin, St. Lucie	Internet	www.pdmnet.com
XSspeed!	West Palm, Melbourne, Ft. Pierce	Internet	www.xsspeed.net

Sources: FCC 00-289, 2000, www.wirelesstcp.net, 2000

7.1.7 Satellite Providers

However, terrestrial fixed and mobile providers are not the only wireless choices agribusinesses have. Table 7-15 lists satellite hypercommunications that serve Florida. Satellite technology was covered in 4.4.3, where the types of satellites (such as GEOs, MEOs, and LEOs) were discussed along with technical details.

Table 7-15: Leading satellite carriers serving Florida.

Provider	Type (coverage)	Services	Deployment
AstroLink	GEO (Ka-band, worldwide)	All	2003
DirecPC	GEO (N. America & Europe)	Cable TV, Internet (400 kbps, downlink only)	Now
ESat (Intersputnik)	GEO (worldwide)	Internet, redundant network access	Unknown in Florida
GE*Star Americom	GEO (C-band, Ku-band, N. America & Europe)	Internet, data networking	Now
Intelsat	GEO	All (Broadband VSAT)	Now
Loral SkyNet	GEO (N. & S. America)	Backup data networking	Now
Spaceway (Galaxy-Hughes)	GEO (Ka-band, worldwide)	Internet, data networking	2002
Tachyon	GEO (worldwide)	Internet to 2 Mbps	Now
Wild Blue (iSKY, KaStar)	GEO (Ka-band, U.S.)	Internet	2002
New ICO (Teledesic, McCaw)	MEO (S-band, C-band, worldwide)	3G MSS	2003
OrbLink (Orbital)	MEO	Unknown broadband services	2002
OrbComm (Orbital-Teleglobe)	LEO (worldwide)	Two-way paging, tracking	Now
GlobalStar	LEO (C-band, L-band)	Mobile and fixed telephony	Now
Leo One	LEO (Worldwide)	MSS: paging, tracking	2003
SkyBridge	LEO (Ku-band, worldwide)	All	2002
Teledesic	LEO (Ka-band, worldwide)	All	2004-2005

Sources:iSky.org, individual websites.

At present, many satellite carriers face substantial delay in entering the market due to the formidable technical process required to establish a working network. Therefore, for systems not yet operational, a deployment date was taken from each firm's website. Additionally, there is a great diversity in services among satellite carriers. Satellite CPE is often expensive and airtime may be subject to a MOU (Minutes of Use) or kbps transmitted charge regardless of the service. However, technology is developing quickly, as is competition so prices are likely to fall while choices and capacity rise.

7.1.8 Guidelines for Choosing a Carrier

Several dozen prospective carriers have been listed in this section as it covered everything from ILECs to satellite carriers. The sheer number of potential carriers may make a decision seem more difficult to agribusinesses. With this in mind, Table 7-16 gives five guides for choosing a carrier.

Table 7-16: Guidelines for Choosing a Carrier

Guideline	Comment
1. Use a strategy based on convergence	Formulate a hypercommunications strategy that includes telephony, enhanced telecommunications, data networking, and Internet.
2. Consider outsourcing implementation	Agribusinesses can focus on their business instead of tracking hypercommunications invoices, soliciting bids, evaluating new technologies.
3. Be careful before signing long-term contracts	Pricing may be low on a five-year contract, but the risk of being trapped in an obsolete technology is high.
4. Most prices are negotiable	Bandwidth and disk space are becoming inexpensive commodities as competition increases. Agribusinesses in competitive areas should have some bargaining power especially on installation and provider-owned or leased CPE charges.
5. Beware of QOS problems	Review Table 4-13 (wireless QOS) and Table 4-3 (15 dimensions of QOS). Be willing to accept more down time than in the days of the Bell System or pay higher prices. Consider having a redundant (backup) communications network.

The five guidelines listed above are straightforward. However, a bit more detail is still needed on three of the guidelines in Table 7-16. First, every agribusiness would do well to understand that communications by telephone and by computer are converging into a single form. Not all agribusinesses in Florida are in a location where they have a single provider who can fill their voice and data needs, nor is one-stop shopping always the answer. However, hypercommunications' rising importance means that all agribusinesses need to prepare for the day that (instead of many providers selling many products) fewer providers will sell one product.

The second guideline may be a lifesaver to many harried agribusiness managers. Many firms have lost control of hypercommunication expenses, although costs are falling and the importance of using hypercommunications intelligently grows. Just as many businesses trust a travel agent to understand the nuances and complexities of air travel reservations, so too will some agribusinesses trust telecommunications consultants or other intermediaries to represent them on the information superhighway. Like a travel agent, an outside agent can only help agribusinesses that know where they want to go.

The middle two guidelines will become even more apparent in the next section. The final guideline to beware of QOS problems should also be obvious to readers of 4.2. There is a tradeoff between a new business world full of inexpensive, high-speed, and high-capacity hypercommunication services and the predictable reliability of the days of the Bell System. If occasional communications down time is serious enough, it may be necessary to have a redundant network ready to go in an emergency. In any event, all agribusinesses should be able to communicate (at least on a minimal basis) during a power outage, natural disaster, or network outage.

7.2 Convergence and Costs of Hypercommunications

The influence of convergence on the communication costs born by agribusinesses and on carrier prices is by no means clear. Many expect the cost of certain familiar sub-markets to continue to fall: long-distance rates have plummeted to under 4 cents a minute, wireless rates are reduced as new bundled plans are offered, and Internet access has become especially competitive.

In addition, one of the most important reasons convergence is occurring is so that total communication costs for a firm will fall because one or two carriers will be paid rather than four or more, even while volume will rise. QOS is another matter, however.

According to Varian, "If you ask an economist to predict what's going to happen to pricing in this industry, the first thing he'll say is we should expect to see price discrimination or product differentiation." [Varian, 1996, p. 47] However, that point would appear to conflict with the overarching technical consensus that hypercommunications convergence is arriving. Importantly, as bits become a commodity and bandwidth becomes known as the size of the container the bits travel in, product differentiation and price discrimination might be more difficult rather than less difficult. However, a complete analysis of pricing and hypercommunication costs using the conceptual model (introduced in Chapter 5) will support Varian's claim.

This section looks at the conceptual model and how it helps describe four cases: cost sensitivity by customer size (7.2.1), pricing based on customization (7.2.2), pricing based on supply segmentation (7.2.3), and converged pricing (7.2.4). Before doing that, however, there are two simple tasks. First, an intuitive argument is presented to show that unless agribusinesses understand the basics of pricing, they will be at the mercy of an industry known for using its customers' ignorance to great advantage. It is for this reason that the second task, the reintroduction of the conceptual model is done. The model becomes more realistic through a decision tree framework that should help an agribusiness manager see where his firm's hypercommunications strategy (or portfolio) fits in the market.

When it comes to hypercommunication prices, getting exact figures can be difficult. As Greg Tally of *Boardwatch Magazine* writes concerning the difficulty of collecting pricing for the magazine's annual *Directory of Internet Service Providers*:

> Even for an institution with corporate buying power, the standard prices for T-1 or T-3 connectivity remain expensive. Most folks wouldn't buy a Cadillac without looking at the sticker price . . . These companies (who refuse to release

> prices) also beg the question: If the Boardwatch editors have this hard a time obtaining routine pricing, how will the average customer fare? [Tully, 2000, p.4]

Furthermore, one a price is obtained, that figure can be illusive. It seems that prices are falling and rising simultaneously and have been for years. Mitchell and Srinagesh explain that while "the history of leased-line prices in recent years reveals a strong downward trend", officially, prices have been rising by 5 to 7 percent a year [Mitchell and Srinagesh, 1997, p.103]. They quote an industry expert who explains why:

> There are two types of tariffs: 'front of the book' rates, which are paid by smaller and uninformed large customers and, 'back of the book' rates, which are offered to the customers who know enough to ask for them. The 'front of the book' rates continue their relentless 5 to 7 percent annual increases. [Quoted by Mitchell and Srinagesh, 1997, p.103]

Thus, it should be clear that one way hypercommunication carriers price discriminate is to segment the market into buyers who understand prices and buyers who do not.

To better understand pricing and costs, it is sensible to see how the topic fits in with what has already been discussed, especially the material in Chapter 6 and in 7.1. Figure 7-3 shows that the conceptual model (originally introduced in 5.6.1) is a useful foundation to understanding pricing. The conceptual model delineates several kinds of costs; each associated with a particular level of the market and effect on an agribusiness' assets, sales, and costs.

C&I (CPE and Installation) costs represent the fixed capital-budgeting costs agribusinesses incur when they purchase a particular technology on the agribusiness side of the demarcation point. These costs occur at each location where the agribusiness plans to set up a communications network.

In Figure 7-3, C&I represents telephone systems, computer systems, PBXs, and training costs needed by agribusiness to upgrade their own local equipment to new forms of communication with other locations, other firms, and customers. The CPE portion of C&I is typically thought of in the same way as acquisition of plant and machinery, as a depreciable asset.

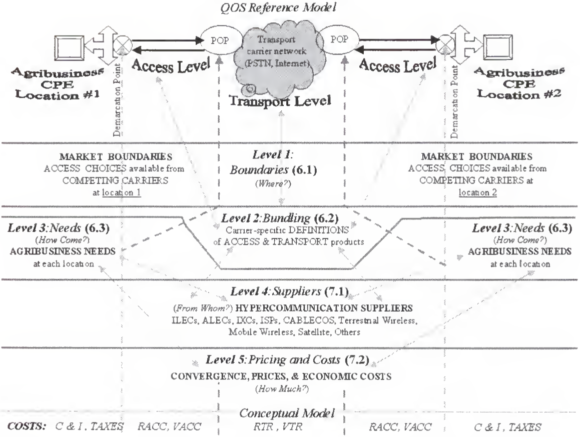
QOS Reference Model
POP
Transport carrier network (PSTN, Internet)
POP
Agribusiness CPE Location #1
Demarcation Point
Access Level
Transport Level
Access Level
Demarcation Point
Agribusiness CPE Location #2
MARKET BOUNDARIES
ACCESS CHOICES available from COMPETING CARRIERS at location 1
Level 1: Boundaries (6.1)
(Where?)
MARKET BOUNDARIES
ACCESS CHOICES available from COMPETING CARRIERS at location 2
Level 3: Needs (6.3)
(How Come?)
AGRIBUSINESS NEEDS at each location
Level 2: Bundling (6.2)
Carrier-specific DEFINITIONS of ACCESS & TRANSPORT products
Level 3: Needs (6.3)
(How Come?)
AGRIBUSINESS NEEDS at each location
Level 4: Suppliers (7.1)
(From Whom?) HYPERCOMMUNICATION SUPPLIERS
ILECs, ALECs, IXCs, ISPs, CABLECOS, Terrestrial Wireless, Mobile Wireless, Satellite, Others
Level 5: Pricing and Costs (7.2)
CONVERGENCE, PRICES, & ECONOMIC COSTS
(How Much?)
Conceptual Model
COSTS: C & I, TAXES
RACC, VACC
RTR, VTR
RACC, VACC
C & I, TAXES

Figure 7-3: The conceptual model is the foundation to understanding hypercommunication costs.

RACC and VACC represent the recurring and variable costs for access to hypercommunications network. In Figure 7-3, both can occur for agribusiness location one and for agribusiness location two. Between the local and remote access levels, is the transport level where recurring transport (RTR) and very short-run variable transport costs (VTR) occur.

Table 7-17 gives examples of each kind of charge for several services and carrier types to clarify the four kinds of costs. From the table, it should be clear that recurring costs are normally regular monthly charges of a fixed amount such as Internet access, or telephone line charges. The recurring costs are non-traffic-sensitive since they do not depend directly on how much communication occurs on a daily basis. The variable costs are traffic-sensitive charges such as long-distance MOU (Minutes of Use) tolls that do depend on day-to-day communications volume.

Table 7-17: Examples of four kinds of costs in conceptual model

Service	RACC	VACC	RTR	VTR
Local telephony from ILEC, single or multi-line	Monthly fee for service, per line	Toll charges on intra-LATA LD, information, operator. (If applicable)	Per-line taxes and regulatory fees	
Local telephony from ALEC, ISDN-PRI 23 digital lines	Monthly fee for local access, per 23 ALEs	Often none	Taxes and regulatory fees lower than per-line local.	
Long-distance telephony from pre-subscribed IXC, single line.			Monthly fee or "plan" charge, if applicable	Per minute MOU toll charges.
Long-distance T-1, 23-24 ALEs	Monthly fee for point-to-point T-1 from agribusiness to IXC POP	NA	Plans and carrier policies vary. Often, there is an RTR for up to a certain number of minutes and an MOU (VTR) toll after that.	
Enhanced telecommunications circuits	See ISDN-PRI above or LD T-1.			
Dial-up Internet access	Monthly charge for access line to telco	Possibly, per hour or per minute long-distance charges if ISP POP is not a local call	Monthly charge to ISP for ISP to Internet backbone (transport)	Possibly, per hour charge for 1-800 access or for hours above plan maximum.
Dedicated Internet access (T-1)	Monthly charge to telco for T-1 (access to ISP POP)	Usually not.	Monthly charge to ISP for ISP to Internet backbone (transport)	Usually none.
Private data networking circuits	Similar to dial-up or dedicated wireline Internet, above			
Dedicated Internet access, wireless	Not applicable		Monthly charge for combined access and transport	Usually none.
Wireless Local Loop (telephone)	Varies from single fee for unlimited use local and long-distance to similar to wireline local.			

The communications needs of an agribusiness and the number and types of hypercommunication suppliers serving a location lead to many possible answers to the last question, "*How much?*" do (or will) hypercommunications cost. However, the answer depends on whether the question is asked on an annual basis, on a first year basis (the first year new a new service is installed), on a monthly basis, or on a variable basis. By considering all four of these cost periods, an agribusiness can make an intelligent comparison among carriers, services, and technologies.

For example, long-distance rates of under $0.03 per minute on an open contract may be available to one agribusiness, but another may have to pay $0.15 per minute or more. Some agribusinesses pay long-distance carriers twenty cents per hour for calls with a wholesale price of below two cents, leaving their long-distance carrier an 18-cent markup (90% of the price of a long-distance call). Another agribusiness, located next door, may pay one-fifth that rate for identical calls even at the same monthly volume. With greater traffic volume or non-PSTN technologies, rates may be well below "wholesale". To get the cheapest long-distance rates, a carrier may require the agribusiness purchase or lease equipment, pay recurring charges on a five-year contract, purchase Internet or data circuits, or guarantee that at least 20,000 minutes per month will be purchased.

Since carriers commonly bundle services in one way but price them in another way, a comprehensive guide to hypercommunications prices throughout Florida is impossible. Even if data for such a guide were available, new products, expansion into new service areas, mergers, and price changes would make it dated material in hours. Therefore, the prices available to a particular agribusiness within a particular area cannot be foretold with precision. However, price ranges and a process for helping agribusinesses to feed in the combination of up-front and recurring costs, (along with QOS details) should make choices and options better understood.

The conceptual model can be used to compare pricing among k different carriers in the following way. Costs become clearer when the model from 5.6 is extended over i service offerings[7] within j particular classes of service (forms of communication). In Chapter 5, four classes of service were listed (real-time voice conversation, one-way text messaging, one-way data or graphics messages, and interactive, collaborative multimedia two-way messages), but there are certainly more. In equation form, the model is written:

$$\mathrm{COST}_{ijk} = f\,(\mathrm{C\,\&\,I}_{ijk}, \mathrm{RACC}_{ijk}, \mathrm{RTR}_{ijk}, \mathrm{VACC}_{ijk}, \mathrm{VTR}_{ijk}, \mathrm{OTHCOSTS}_{ijk}; \mathrm{TAX}_{ijk}, \mathrm{QOS}_{ijk}).$$

Where:

COST represents the economic cost to an agribusiness of service offering i within class j for carrier k, during the recurring period.

C&I is the LR fixed cost of CPE and installation over ijk

RACC is the SR recurring cost for network access over ijk

RTR is the SR recurring cost for network transport over ijk

VACC is the VSR variable cost for access over ijk

VTR is the VSR variable cost for transport over ijk

OTHPRICES are costs of available substitutes and complements

TAX is a set of taxes and charges over ijk

QOS is a vector of Quality Of Service characteristics over ijk.

It is important to understand that the period in which variables are measured makes an important difference in which options are most attractive. Furthermore, the economic or opportunity costs of one choice or another must also be kept in mind. For example, a firm might save twenty percent on the monthly local telephone bill and fifty percent on long-distance by buying an IP CTI PBX (Internet Protocol Computer Telephone Integration Private Branch Exchange System) and replacing the old telephones. However, the time it takes workers to understand how to use the new system and the fixed cost of buying the equipment have to be factored in over some kind of discount or payback period.

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[7] The service offering in this sense is a combination of a particular service bundle offered with a particular hypercommunications technology.

It is impossible to use the model to show everything that an agribusiness might need in the way of hypercommunications. The list is a long one including local telephony, long-distance telephony, private data networking, enhanced telecommunications, Internet, mobile telephones, wireless messaging (pagers), etc. For this reason, it helps to think of an agribusiness' hypercommunications portfolio in the same way an investment portfolio would be thought of.

Carriers have created portfolios of services with the idea of extracting maximum revenue from their customers and steering them to the most profitable service bundles. Similarly, agribusinesses need a hypercommunications portfolio based on their own strategy and business philosophy or end up with a solution that is unsatisfactory. Figure 7-4 illustrates how an agribusiness might decide on a portfolio. The portfolio tree shown is something like a decision tree except that it can be used for broader, more open-ended situations than a decision tree [Wind and Saaty, 1980, p. 650]

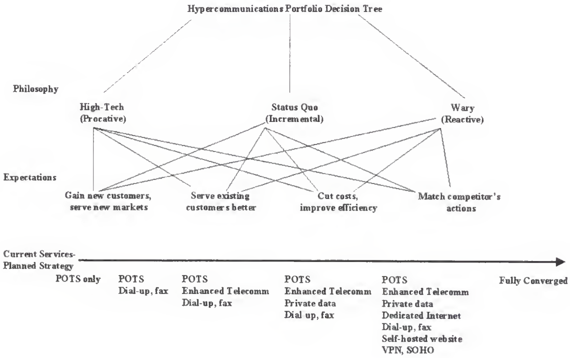
Hypercommunications Portfolio Decision Tree
Philosophy
High-Tech (Procative)
Status Quo (Incremental)
Wary (Reactive)
Expectations
Gain new customers, serve new markets
Serve existing customers better
Cut costs, improve efficiency
Match competitor's actions
Current Services-Planned Strategy
POTS only
POTS Dial-up, fax
POTS Enhanced Telecomm Dial-up, fax
POTS Enhanced Telecomm Private data Dial up, fax
POTS Enhanced Telecomm Private data Dedicated Internet Dial-up, fax Self-hosted website VPN, SOHO
Fully Converged

Figure 7-4: Hypercommunication portfolio tree.

An agribusiness starts by understanding what its philosophy is concerning technology at the top level in Figure 7-4. Some agribusinesses have a high-tech philosophy that is proactive or embraces new technologies before they are proven in the hopes of being innovative leaders. These agribusinesses are comfortable with making hypercommunications decisions in leaps instead of baby steps. For example, such a firm might be very willing to embrace the IP CTI PBX example above, although it knows the short-term economic cost will be high. The proactive philosophy plans for anticipated future growth and needs well in advance but risks having too much capacity.

Other agribusinesses, more cautious, make changes in their communications in small steps, the status quo incremental approach. These firms might try a new service for a new office or a few new employees and change existing equipment slowly over time. The risk of making a bad decision on new technology is large enough that the incremental philosophy resists company-wide change, favoring test programs or waiting until the company occupies a new building or the employees are ready. The incremental philosophy waits until the current communications network and equipment is showing signs of excess traffic and then acts.

An agribusiness with the wary philosophy is reactive as concerns technological change. It will wait until competitors have adopted new technologies so that it can learn from their mistakes or wait until prices go down. This philosophy is not anti-technology, but simply weights the risk of making changes far more strongly than possible benefits, even if those benefits are likely. These firms gather an enormous amount of information over time and shop carefully for proven technologies. The reactive philosophy waits until the current network is ready to fail.

Given one of the philosophies, each firm can choose one or more of the communications expectations at the next level of the portfolio tree. While the expectations are not mutually exclusive, a greater amount of effort must be expended for each communications expectation. The idea is simply to have an idea of what it is the agribusiness wants hypercommunications to accomplish and when.

Finally, it is time to choose tactics. Each firm has a starting point on the current services-planned strategy continuum that goes from analog POTS only on one end to a fully converged solution on the other end. The proactive firm may be willing to skip several options to travel in the converged direction, while the incremental may move one to the right at a time, and the reactive will wait to see what competitors do before acting. A process like this can be useful in planning a hypercommunications strategy.

In the rest of the section, the model will be used to examine some sample agribusiness hypercommunication decisions. The choices a particular agribusiness will make will depend on all of the factors mentioned in earlier chapters along with philosophy and expectations.

7.2.1 Cost Sensitivity by Customer Size

The hypercommunication choices available to an agribusiness and costs incurred depend on the scale of the agribusiness but not as much as they used to. This can be seen in two ways. First, from the point of view of a growing agribusiness and second from the viewpoint of unequally sized competitors.

A growing agribusiness must plan to "grow into" its hypercommunications CPE and services. Many decisions to change hypercommunication are based on expected future growth, moving to new offices, adding a new location, or gaining a sizable new customer base that justifies a change.

Pricing is sensitive to the scale of the firm for both economic and technical reasons. One example of cost sensitivity by customer size can be seen with Internet access. As a starting position, a firm may face the situation in Table 7-18. Assume that the cost of the computer, telephone set-up, and Internet installation has long been paid for so that C&I is zero. The cost per month (assuming the telephone line is always available to be used for the Internet and that there is no use above the 150 hour ceiling put in place by the ISP is $76.55.

Table 7-18: Initial situation, cost sensitivity by customer size

Service	RACC	VACC	RTR	VTR
Internet, dial-up	$56.60	None	$19.95	$1.00 hour over 150

The dial-up solution might be fine unless the firm frequently went over the 150-hour limit or suffered losses because of the slow connection. Even with just one employee, it is possible that the dial-up would not be enough for technical or economic reasons. An important question occurs if the firm knows that it can purchase a dedicated 128 kbps frame relay circuit along with a C&I cost of zero (carrier pays for installation, CPE, and set up).

Suppose the firm had several employees, it might want to know at what size (how many employees) it should convert from dial-up to dedicated. The answer depends on the data in Table 7-19. Dedicated Internet via a frame relay connection appears to be cost effective for 13 or more employees. Dedicated Internet using ISDN-BRI might appear to be cheaper than 12 dial-up users, except that BRI has an hourly charge since it is a switched ILEC circuit. (It does allow telephone use while online, however, which should count for something.) The wireless option has an even lower conversion point at under eight dial-up users.

Table 7-19: Finding the conversion point, cost sensitivity by customer size

Service	RACC	VACC	RTR	VTR	Total (mo.)
Internet, dial-up	$56.60	0	$19.95	$1.00 hour over 150	$76.55+?
12 users, dial-up	$679.20	0	$239.40	?	$918.60+12x?
13 users, dial up	$735.80	0	$259.35	?	$995.15
Internet, dedicated 128 kbps frame relay	$379	0	$600	0	$979.00
Internet, wireless	0	0	$550	0	$550.00
Internet, dedicated 128 kbps ISDN-BRI	$283	Per hour charge	$600	0	$883.00+?

Importantly, there are many factors other than accounting price and number of employees involved. If it was extremely important to be online all the time so as not to miss e-mails and orders, for example, the conversion point might be for fewer employees. The capacity of the circuit would also matter, if 10 people were regularly online at once sending e-mails with large graphics attachments, a 128 kbps connection could be insufficient. However, since the frame relay circuit is burstable with the possibility that a lesser (or greater) capacity would be available for use on occasion depending on the contract specifications, it is not precisely comparable with the ISDN-BRI. Another important factor is that VTR and VACC are often uncontrollable expenses since they are traffic sensitive. While assumed to be zero, these expenses could become higher than the recurring cost under some circumstances. Finally, the value of time saved by not having to wait as dial-up connections are established must be considered.

The central problem of any hypercommunications provider is to maximize profits while minimizing the total cost of capacity while also maximizing the probability that users will not suffer blockages or congestion. Thus, the QOS dimensions must always be considered because even if the used a free Internet dial-up instead of a dedicated connection, there would be an opportunity loss of time from busy signals and ad loading times to contend with. In short, the conceptual model should be considered a useful first step to making a decision, but must always be accompanied by more information.

7.2.2 Pricing Based on Customization

Another important factor in price concerns what is called customization in most other goods. Here is where Varian's point that opened the section becomes important. Prices vary according to factors such as QOS guarantees (SLAs), traffic priority, technical support, and degree of network management offered by the carrier. Firms are often willing to pay more to have a provider manage their network, whether through managed router service for Internet or data networking or through virtual PBXs hosted at the telephone company.

7.2.3 Pricing Based on Traffic Segmentation

A final price impact comes from pricing based on traffic priority, time of day, etc. One example is the ability of ATM to offer smart pricing. For each communication, the first step before transmission is to tell whether network has capacity, then routing and the highest revenue "call" are chosen. Key explains how this works:

> Connection admission control (CAC) says how and when calls should be admitted to a network. ATM is connection-oriented, and when a connection arrives at the network boundary, the network has to decide whether to admit the call or not. At this stage, a contract negotiation occurs --- the user declares a set of requirements to the network, and the network agrees to carry the call at a given quality of service. Renegotiations can take place if the network is unable to satisfy the user's initial demands. In practice, this whole process may be transparent to the user, with terminal equipment communicating with the network automatically.
>
> In a network, call admission control, routeing, congestion control, and tariffing are all intertwined. In a lightly loaded network all calls will be accepted, whereas when the load increases, certain calls will be rejected. Some might be rejected because the network is unable to carry them without compromising the quality of service of other calls (lack of capacity), and others will be rejected because the network prefers to wait for a higher revenue call to arrive. Whether the network can accept a new connection depends on the flexibility of the routeing strategy --- there may be spare capacity in unused parts of the network, whereas preferences amongst call types depend partly on tariffing issues….Routeing and tariffing can be thought of as second-order effects which can be looked at once the basic problem (deciding whether there is enough capacity in the network to admit a call of a particular type) has been identified and answered. [Key, 1997, p. 124]

ATM can automatically prioritize traffic, just as certain intelligent telephone systems can automatically select the cheapest long-distance provider for a particular time of day and call destination. However, these kinds of technologies are so expensive that they are generally affordable only by carriers or very large agribusinesses.

Many economists suggest that this approach is superior to the Internet's available bit rate approach. Under the 'available bit rate' or traditional closed-loop approach of the Internet, as loads increase, spare capacity is exhausted. New connections are allowed, but everyone's QOS is subject to slowdown. This strategy is optimal if the utility or value that users place on the bandwidth is a concave function [Shenker, 1995]

7.2.4 Convergence Among Service Classes

As classes of service (telephone, data, and Internet) converge it is likely that total costs for many agribusinesses will fall substantially. However, in some cases, true economic costs could rise if the agribusiness follows the wrong hypercommunication strategy or does not follow one at all. The central idea here can be shown quickly in the following example for an imaginary firm with 10 telephone lines (multi-line), 2 fax lines, 5 modem lines, and a 56 kbps DDS data networking circuit at one location. The initial situation is shown in Table 7-20.

Table 7-20: Initial situation, convergence among service classes

Item (quantity)	RACC	VACC	RTR	VTR	Total (mo.)
Internet, dial-up (5)	$56.60	0	$19.95	$1.00 hour over 150	$382.75
Local POTS (10)	$56.60	$0.10, inter-LATA LD			$566.00
Fax lines (2)	$56.60				$113.2
DDS (1x56kbps)	$429.00	0	0	0	$429.00
Long-distance (8,000 min, avg.)				$0.08	$640.00
				Total	$2130.95

The firm could migrate to a single converged provider who provided a smart-T product where for $1050.00 per month it had 24-64 kbps channels that could be automatically allocated to voice or Internet. Carriers with such smart T's might require that the agribusiness purchase (or lease) the CPE and require a maximum long-distance of 5,000 minutes per month at $0.10 per minute. In such a case, although the VTR would rise to $0.10 (to total $800.00 per month on average), total monthly expenses would fall to $1,850.00 per month. That would be on a greater amount of communications since the firm would have over 20 local telephone lines (compared to 10 usable lines before), as well as greater Internet connectivity (on a burstable basis), and free inter-LATA long-distance calls. This kind of scenario is precisely what is happening in Florida as hypercommunications convergence occurs. In many cases (especially for larger businesses), the savings are greater and the gain in communications capacity larger. However, this example shows that relatively small businesses can benefit from consolidating their telecommunications circuits into a hypercommunication network access connection.

7.3 Recommendations Concerning Agribusinesses Hypercommunications

Jakob Neilsen describes four situations facing consultants who deal with business communication needs:

> Client is clueless: needs a truck but asks for a bus. Consultant says 'Yes, Sir/Madam' and builds a bus as ordered. Client is clueless: needs a truck but asks for a bus. Consultant carefully explains why it would be better to build a truck. Client is clueless: asks the consultant to build something that moves. Consultant analyzes the client's needs carefully and builds a truck. . . . Of course, there is a fourth possibility: the consultant is (also) clueless. [Neilsen, 1998, p. vii]

In each case, the "clueless" client requires the services of an outside consulting firm to navigate their communications options. Hypercommunications is both complicated and important enough that a consultant or well-trained internal staff member or both may be needed to advise decision-makers.

Figure 7-5 shows that hypercommunications and network strategies for agribusiness are concentrated in four interrelated areas. In the first area, there are capital budgeting decisions regarding CPE purchases and other technical decisions (called C&I in the conceptual model). In the second area are recurring expenses known as RACC and RTR in the conceptual model. A third area concerns operations changes needed to benefit from and implement hypercommunications and networking strategies. This third area includes new products, new processes, and new employees and how the agribusiness changes (internally and philosophically) to meet the challenges of an information-driven new economy. Variable costs of hypercommunication (known as VACC and VTR in the conceptual model) are closely linked to changes in operations but also depend on recurring expenses.

The fourth and last area includes software, redundancy, management, and upgrade decisions. The basis for decisions in this last area should be apparent from discussions in other chapters, where some are explained in more detail. Software, redundancy, and upgrades are a mixture of risk decisions and planning. All were discussed earlier. For example, telemanagement (the system put in place so that billing, details about extensions, telephone locations, and other details of hypercommunications) was covered in Chapter 4.

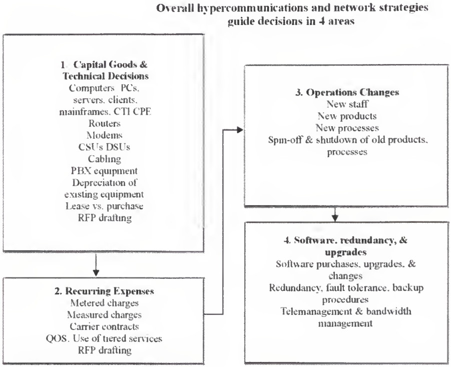
Overall hypercommunications and network strategies guide decisions in 4 areas
1. Capital Goods & Technical Decisions
Computers PCs, servers, clients, mainframes, CTI CPE
Routers
Modems
CSUs DSUs
Cabling
PBX equipment
Depreciation of existing equipment
Lease vs. purchase
RFP drafting
2. Recurring Expenses
Metered charges
Measured charges
Carrier contracts
QOS. Use of tiered services
RFP drafting
3. Operations Changes
New staff
New products
New processes
Spin-off & shutdown of old products, processes
4. Software, redundancy, & upgrades
Software purchases, upgrades, & changes
Redundancy, fault tolerance, backup procedures
Telemanagement & bandwidth management

Figure 7-5: Hypercommunications strategy guides agribusiness IT and hypercommunication decisions.

The scope of the discussion of pricing and costs does not extend to detailed engineering or technical purchase decisions concerning capital goods such as CPE. However, there can be an important relationship between carrier prices and CPE investments required by an agribusiness. Recall from earlier discussions that carriers often bundle CPE (capital goods and technical decisions) with their rates. Recall additionally from 4.5 that support services and employment costs are actually a larger share of the total communications budget than CPE or carrier bills. However, such expenditures are often not chargeable directly to IT or telecommunications.

Florida agribusinesses have two essential jobs as they strategically manage adoption and use of hypercommunications to benefit from the economic reality behind these two slogans. One job is to plan for an array of new opportunities in communications, production, marketing, and control made possible by hypercommunications networks. A large set of opportunities (things that could go right) for agriculture are enhanced by hypercommunications. Hypercommunications services allow communications costs to fall even as communicating distances and volumes rise, more efficient marketing, better coordination with suppliers, access to new markets, and a host of other benefits. Properly understood and carefully budgeted, hypercommunications help agribusinesses to cut costs, raise revenues, serve customers better, and achieve greater efficiency. On the opportunity side, agribusiness, like any other sector of the economy, can help things to go right by understanding hypercommunications.

However, managers also need to do a second job, understanding the set of things that could go wrong, along with planning some possible preventative strategies. Some problems will result from not adopting new hypercommunications services, while some of problems will be because of adopting new services. Still other problems will be due to factors beyond any firm's control. For example, many Florida agribusinesses could be left behind if the state's hypercommunications infrastructure develops too slowly in specific locations.

Furthermore, uneven regulation, a lack of competition in hypercommunications services, and a shortage of qualified personnel (who can shop for and implement better hypercommunications in agribusiness) threaten to turn the promise of high tech into a managerial headache. In addition, on the problem side, an expensive Pandora's box of difficulties may beset ill-prepared firms who rush into poorly researched hypercommunications decisions.

Additionally, departments inside each agribusiness have their own strategic concerns regarding hypercommunications. Advertising and marketing, administration and production, recruiting and human resources, transportation and logistics, research and development, receivables and payables, and (of course), computing and telecommunications each have needs. Unless managers are careful, the development of a hypercommunications strategy can lead to turf wars and infighting, especially in large firms. For smaller firms without distinct departments, a lopsided strategy can still harm specific functions.

Table 7-21: Implications of convergence and recommendations for agribusiness strategies

Implication	Recommendation	More reading
Convergence is going to unseat telecommunications and replace it with hypercommunications.	Agribusinesses need to understand how the telecommunications model differs from the hypercommunications model.	2.2.3, 4.1, Table 2-1
It can be easy to be caught up in the idea that "unlimited" communication is creating a completely "new" economy.	Beware of anything that claims to be unlimited. The new economics of the network has interesting and unexpected possibilities, but they are hardly unlimited.	2.5, 3.7.5
Pressure is on to increase business bandwidth.	Understand why bandwidth and speed are not identical.	4.2.1, Table 4-2
All providers, services, and technologies are not equal, even if they appear the same.	Understand QOS (Quality of Service)	4.2.4, Table
Traditional telephony service has been upgraded to serve customers and businesses better.	Learn about enhanced telecommunication services, how they can benefit even small agribusinesses, how competition lowers bills	4.6, 4.7, 7.1, Table 4-16, Table 4-17
Hypercommunication pricing is and hard to understand	Follow the guidelines for choosing a carrier.	Table 7-16
Websites are increasingly important to most businesses.	Understand the basics of design, promotion, and measurement, and how e-commerce works.	4.9.4, 4.9.5, 4.9.9, Table 4-37
Taxes in Florida on telecommunications are high, can be over 28% of cost.	Learn what the difference between a mandatory tax and an optional regulatory fee are, as well as what services incur lower taxes.	5.5.2, 5.6.4, Table 5-13, Table 5-14
Agribusinesses have plenty of unique needs for hypercommunications	See how agribusiness is responding to the information economy through innovation.	6.3, Table 6-16, Table 6-17
Location and infrastructure (not necessarily money) determine who has the best services.	New services such as fixed wireless and DSL are cheaper than many alternatives, but are available only in parts of Florida.	5.2, 6.1

Table 7-21 gives ten of the many recommendations for Florida agribusinesses regarding hypercommunications strategy given in this study. Because there are many facets involved in such a technically and economically complicated area, it is hard to boil down the main implications into only ten. However, Table 7-21 is an attempt. Details will be found in the section of the text mentioned in the table.

7.4 Conclusion: Convergence is Here

For Florida agribusinesses the promise of unlimited communications, brings a combination of excitement, confusion, and even danger. For rural communities and some segments of agriculture, hypercommunication is often heralded as an economic development savior, but is just as often criticized as an oversold dream. Much of the debate about what hypercommunications may or may not mean to agribusinesses or rural Florida sounds more normative than positive. Once arguments in the debate are spelled out, economic reasoning can be used to suggest the desirability of merging the information economy, communications technologies, and agribusinesses .

Yet, whether optimistic or pessimistic, most observers agree that the information age will transform agriculture. However, the speed with which the transformation will happen and the transformation's impact on particular agricultural sub-sectors are subject to debate. Much of that debate probably depends on whether Moore's Law or Metcalfe's Law win out as far as technological change on Florida's agribusiness sector.

Lucky defines Moore's Law in the following passage.

> We all seem to view the world through linear glasses -- if something grows by a certain amount this year, it will grow an equal amount next year. But according to Moore's Law, electronics that is twice as effective in a year and a half will be sixteen times as effective in 6 years and over a thousand times as effective in 15 years. This implies periodic overthrows of everything we know. An executive in the telecommunications industry recently said that the problem he confronted was that the 'mean time between decisions exceeded the mean time between surprises'. Moore's Law guarantees the frequency of surprises. [Lucky, 1997, p. 3]

However, the optimism of Moore's Law is tempered by Metcalfe's Law.

> There is another 'law' that affects the introduction of new technology -- this time in an inhibiting fashion. Metcalfe's Law, also known to economists generally as the principle of network externalities, applies when the value of a new communications service depends on how many other users have adopted this service. If this is the case, then the early adopters of a given service or product are disincented, since the value they would obtain is very small in the absence of other users. In this situation innovation is often throttled. . . . A classic example, of course, is the videotelephone. There is no value in having the first videotelephone, and it only acquires value slowly as the population of users increases. If there are n users at a given time, then there are n(n-1) possible one-way connections. Thus, the value grows as the square of the number of users. [Lucky, 1997, p.4]

Throughout this study, there has been an ongoing contest between technical efficiency (represented by Moore's Law) and economic efficiency (represented by Metcalfe's Law). However, the future depends on more than efficiency. Technological change in agribusiness also depends on infrastructure (human and physical) and the adaptability of people and organizations to change.

Promising results for agriculture can occur from cooperation between education and agribusiness. The speed with which technologies are adopted depends on how well universities, schools, and agriculture organizations do at teaching (and selling the usefulness of) technology. For a particular citrus grower or row crop farmer, educational background and local infrastructure can hold back the usefulness of high technology. Large producers already can make sophisticated use of market information about weather, online futures and stock market trading, and real-time prices.

Video auction and broadcast capabilities for livestock breeders and plant nurseries are just beginning to be used. In the immediate future, super farms such as large sugar, tomato, and citrus operations will be able to take care of logistics in near real-time to co-ordinate harvesting, trucking, and day-to-day operations. Irrigation management, frost warning and protection, and other activities can be performed automatically by remote sensing applications that monitor crop conditions and provide water and nutrients with pinpoint precision and accuracy throughout a farm able to afford such a system. E-farms of the future are envisioned as sustainable, ecologically safer ways to produce food and fiber at low unit costs.

Some have argued that there is a myth of the economy of scale in agriculture. Goldschmidt argues that there is a natural limit to the size of an agricultural operation since:

> The cost efficiency curves...in each instance flatten out at the level of operations that one or two persons can handle and sometimes actually rise with larger operations. Just what the optimum size is varies with crop and other circumstances, but in very few instances do substantial economies appear beyond modest-sized operations, despite their intensive use of mechanization. [Goldschmidt, 1978, p. xxxi]

This thought may be a but a legacy of the old economy if hypercommunications alter the maximum size of agricultural operations because of a wider span of control.

Not that hypercommunications can solve the farm problem or answer every problem faced by agribusiness. Mixed results have been obtained by many agribusinesses already using hypercommunications. Costs for maintaining a WAN (Wide Area Network) that spans several facilities for urban locations and most intra-LATA connections are low in relation to inter-LATA connections or when distance to node becomes large. The Internet might be part of the answer for some agribusinesses to communicate more cheaply, in more detail, and more often. However, Internet security and privacy are definite risks although new software, hardware, and firewalls are thrown into hypercommunications security war to mitigate against threats.

For some agribusinesses with existing experience with WANs, Internet, Intranet, and VPNs (Virtual Private Networks), or voice-grade T-1's, "proceed with caution" might be the advice they would give to other companies. Often, sales, inquiries, and communications have at least paid for the monthly bandwidth bills. However, the company may not have enough trained employees with computer skills, well-functioning equipment, etc. Such firms have to buy new equipment that works in concert and hire consultants. Departments may have turf fights over control of the technology. On the carrier end, technical support may be unaware of how to correct problems it suspects are due to CPE.

On the downright pessimistic side, there are cases of business failure, crime, and even greater evils. System crashes from playful or vandalizing employees, errors that cause private customer data to become compromised, and weeks may go by when carriers do not provide contracted service due to breakdowns. Less frequent, but possible, are hacker abuses, electronic payment fraud, along with pornography and sexual harassment cases that stem from misuse of instant, anonymous communications. Sometimes customers complain of being unable to get through by voice, lost sales or merchandise, or dated inquiries that were never acknowledged or responded to. A poor transition from one hypercommunications system or network to another can cripple and even kill an organization.

The speed of hypercommunications convergence depends on a tradeoff between Moore's Law, Metcalfe's Law, infrastructure development, and the behavioral adoption process, as Lucky argues.

> Moore's and Metcalfe's Laws make an interesting pair. In the communications field Moore's Law guarantees the rise of capabilities, while Metcalfe's Law inhibits them from happening. Devices that appear to have little intrinsic value without the existence of a large networked community continue to diminish in cost themselves until they reach the point where value and cost are commensurate. Thus Moore's Law in time can overcome Metcalfe's Law. [Lucky, 1997, p.5]

The question is how much the behavioral adoption process and infrastructure development rate will slow down the march of change.

Prophetic advice was offered in 1982: "Computers are as expensive toys as video equipment and just as useless if you don't have people with the skills and inclination to make use of them as communication tools." [Lionberger and Gwin, 1982, p. 189] Perhaps the largest limitation on agribusiness use of hypercommunications does not come from outside sources such as infrastructure, competition, or regulation, but from the people and managers that make up an agribusiness.

GLOSSARY

3B2T - A baseband line code where three binary bits are encoded into two ternary symbols. [Schneider, 1999]

4B3T - A baseband line code where four binary bits are encoded into three ternary symbols. [Schneider, 1999]

Alternative Access Vendors --- FPSC designation for carriers who provide local, inter-LATA, intra-LATA, and EAS private line services. The designation allows "dark fiber" providers such as cablecos and municipal, corporate, and co-op electricity monopolies to sell hypercommunication services.

ALEC (Alternative Local Exchange Carrier) --- FPSC designation of local exchange carriers that were not the incumbent monopoly provider for a particular exchange as of 1996. Often known as CLEC (Competitive Local Exchange Carrier), or bypass carrier.

Amplitude Modulation (AM) --- "One of three ways a sine wave signal must be modified to "carry" information. The sine wave, or "carrier" has its amplitude modified in accordance with the information to be translated. " [Martin, 1972:237]

Analog data --- "Data in the form of continuously variable physical quantities." [Martin, 1972: 237]

ARPA (Advanced Research Projects Agency) --- Federal agency (part of or closely working with the Department of Defense) that created the ARPANet which was the foundation of the Internet.

ARPANet --- Department of Defense network that preceded the Internet.

bandwidth --- (for an analog radio signal) "Total width of a radio signal, varying from a few hundred Hz for CW to five or six MHz for TV." [Barden, 1987 p. 109]

bandwidth --- Used to measure the capacity of a particular technology or service to carry hypercommunications traffic. May be further defined as the signal carrying capacity of a segment(s) of a communications link, or as the "width" of a particular communications link.

baud rate (modulation rate) --- "Unit of signaling speed. The speed in baud is the number of discrete conditions or signal events per second. If each signal event represents only one bit condition, baud is the same as bits per second." [Martin, 1972, p. 239]

bit --- "contraction of 'binary digit', the smallest unit of information in a binary system. " [Martin, 1972, p. 239]. In SI units, bit is abbreviated as an un-capitalized b.

bit rate --- Generally, the speed at which bits are transmitted, usually expressed in bits per second. [Martin, 1972, p. 239] The bit rate refers to number of bits in a digital signal stream (contrasted with cycles per second or Hertz for an analog signal) per time unit. "For n-ary operation, the bit rate equals $\log_2 n$ times the rate in bauds, where n is the number of significant conditions in the signal." [GSA, FED-STD-1037C, 1996, p. B-11] The bit rate (number of bits per second) that can be accommodated by any medium is proportional to bandwidth. Therefore, the greater the bit rate, the larger the bandwidth needs to be. The bit rate includes error and overhead.

BOC (Bell Operating Company) --- A particular kind of ILEC that is a direct result of the breakup of the AT&T telephone monopoly. Bell South is a BOC, also called RBOC for Regional Bell Operating Company.

bps (bits per second). Used in connection with bandwidth (capacity), bit rate, and data rate.

Bps (Bytes per second), often expressed with a capital K as in KBps. Not the same as kbps.

Bytes --- In SI units, byte is abbreviated with a capitalized B. A byte typically contains eight bits. Bytes are the units typically associated with digital file storage, while bits are associated with digital communications.

Channel --- "1. CCITT and ASA standard) A means of one-way transmission. 2. (Tariff and common usage) ..."a path for electrical transmission between two or more points without common-carrier provided equipment. Also called circuit, line, link, path, or facility." [Martin, 1972, p.240]

Channel, voice-grade --- A channel suitable for transmission of speech, ..., generally with a frequency range of about 300 to 3400 cycles per second (hertz). [Martin, 1972, p.240]

Circuit --- "A means of both-way communication between two points, comprising associated 'go' and 'return' channels. [Martin, 1972, p. 240]

CLEC --- Competitive Local Exchange Carriers provide local telephone service in competition with ILECs in various markets of the U.S. In Florida, CLECs are known as ALECs.

codec --- (1) Coder-decoder chip or integrated circuit that performs ADC and CAD. (2) compressor-decompressor that compresses large files prior to transmission at the sending and decompresses them at the receiving end.

CZ (Coverage Zone) --- geographic region (land and atmosphere) over which a part icular carrier's signal is typically likely to be available to subscribers (cellular), listeners (radio), and viewers (TV satellite and broadcast). As base stations in the network increase power, the coverage zone expands subject to ground conductivity, terrain, and other conditions.

data rate --- Data rate (also known as line speed) measures "the aggregate rate at which data pass a point in the transmission path", typically expressed in bits per second (bps). [FED-STD-1037C, 1996, p. D-4] When bandwidth is expressed in bps, it represents the maximum attainable data rate in a single direction of a noiseless link with no other traffic. Due to compression, the achieved throughput rate may be greater than the fastest data rate of any network segment between the sender and destination. Data rate is an error-free rate, so it is always less than or equal to bit rate.

data-signaling rate --- Usually the same as data rate.

DNS (Domain Name Service, Domain Name Server) --- an electronic IP address book similar to the white pages in the telephone directory except for the fact that rather than a self-selected sample like the white pages, all active IP addresses and many inactive ones worldwide are listed.

digital signal --- "A discrete or discontinuous signal; one whose various states are discrete intervals apart." [Martin, 1972, p. 243]

DMT (Discrete Multi Tone) --- ANSI/ITU ADSL standard

DSL (Digital Subscriber Line) --- Table 4-21 shows all flavors.

DWMT (Discrete Wavelet Multi-Tone) --- Aware Inc. *de facto* standard for DSL.

EAEA (Equal Access Exchange Area) --- "EAEA's are geographical areas, configured based on 1987 planned toll centers/access tandem areas, in which the Company is responsible for providing equal access to both carriers and end users in the most economically efficient manner. In an EAEA, IXCs and resellers may have one or more point of presence so long as any additional costs incurred by the company in providing such alternate or additional point of presence be paid by the party choosing such location. [FPSC order 13750, Docket 829537-TP October 5, 1984." Bell South, 1996, p.1.]

Efficiency --- bits transmitted and received/ bandwidth capacity [Martin, 1972 p. 239]

EHF (Extremely High Frequency) --- In the electromagnetic spectrum, frequencies from 30 GHz to 300 GHz. [GSA, FED-STD-1037C, p. E-18]

Electromagnetic spectrum --- According to the FCC in 1996 the electromagnetic spectrum is "the range of frequencies of electromagnetic radiation from zero to infinity....by custom and practice, formerly divided into 26 alphabetically designated bands. This usage still prevails to some degree. However, the ITU formally recognizes 12 bands from 30 Hz to 3000 GHz. New bands, from 3 THz to 3000 THz, are under active consideration for recognition. [GSA, FED-STD-1037C, p. E-15]

ELF (Extremely Low Frequency) --- In the electromagnetic spectrum, frequencies from 30 Hz to 300 Hz. [GSA, FED-STD-1037C, p. E-18]

ESF (Extended Super Frame) - Type of framing used with T-1 carriers that allows superior QOS monitoring and problem diagnosis than SF.

ETC (Exempt Telecommunications Company) --- Under the 1996 TCA, Section 103, where the SEC determines that a registered holding company of a public utility provides hypercommunications through a single subsidiary. States must permit the sale of assets from any utility holding company's retail rates to ETC subsidiaries.

Exchange --- "A unit established by a communications common carrier for the administration of communication service in a specified area which usually embraces a city, town, or village and its environs. It consists of one or more central offices together with the associated equipment used in furnishing communication service. (This term is often used as a synonym for "central office" q.v.) " [Martin, 1972, p. 244]. The acronym CO stands for central office.

FM band --- 88 to 108 MHz.

FPSC --- Florida Public Service Commission. The state body that regulates by statute traditional and certain enhanced telecommunications services.

FPSC designation --- The Florida Public Service Commission has the power to certificate communications carriers in Florida. A carrier may be an ILEC, ALEC, or IXC. Carriers may be further certified as STS, AAV, SB, FB, and other designations.

hertz (Hz) --- A measure of frequency or bandwidth. The same as "cycles per second.". [Martin, 1972, p.346]

HDSL (High data rate Digital Subscriber Line) --- Family and specific type of symmetric DSLs. HDSL2 is a more recent standard

HDTV (High Definition Television) --- "systems that offer approximately twice the vertical and horizontal resolution of receivers generally available on the date of enactment" of the TCA. [1996 TCA, Title II, Sec.201, (g) DEFINITIONS]

HF (High Frequency) --- In the electromagnetic spectrum, frequencies from 3 MHz to 30 MHz. [GSA, FED-STD-1037C, p. H-5]

Gbps --- gigabits per second

ILEC --- traditional telephone monopolies that include RBOCs, rural telephone cooperatives and independent companies such as Sprint and GTE who own the outside wire plant (telephone poles, cables, etc.) that link telephone subscribers with the ILEC central office. Unless the "last mile" of ILEC copper access is bypassed, all wireline voice, data, and Internet traffic may have to travel over portions of an ILEC's plant.

internet --- a "network of networks" of electronic equipment, appliances, or computers that has a closed architecture (does not connect to the World Wide Web or allow Internet IP addressing) when compared to Standard 1556.B7, ITU. This includes Intranet, Extranet, VPN, and any other kind of private network.

Internet --- most simply, "internet" a network of networks. In its capitalized form, a network of networks connected to the outside world. Details are found in 4.9.

ISDN-BRI --- 64 kbps to 128 kbps twisted-pair circuit-switched connection capable of simultaneously carrying voice and data.

ISDN-PRI --- A method of circuit-switched transmission of voice and data using 23 64 kbps channels and one D-channel for control.

IXC (Inter-Exchange Carrier) --- long-distance provider offering inter-LATA, intra-LATA, interstate, intrastate and international long distance calling to presubscribed subscribers or to providers of long-distance calls from pay telephones, operator calls, or to dial-around customers.

IY (Internet Years) --- to dramatize the compression of time and the exponential expansion of knowledge that has occurred with the dawn of hypercommunications (especially computer), Internet Years were created. Internet Years are said to be like "dog years". It is as if economic actors must be ready for a full year's worth of technological change and new information and knowledge in one-seventh of an "old" year.

kbps (Thousands of bits per second, kilobits) --- also expressed as kbits s^{-1} the measure is one of data rate rather than speed.

LATA --- Local Area Transport Area --- Created with the AT&T breakup to classify areas within which local telephone companies could operate. The baby Bells (RBOCs) were forbidden to provide inter-LATA service. This rule can be overturned under certain circumstances in the 1996 TCA.

legacy --- A legacy network or system is one that is outdated but somehow necessary for a business to function.

LF (Low Frequency) --- In the electromagnetic spectrum, any frequency in the band from 30 kHz to 300 kHz. [FTC-STD-1037, p. L-10]

Mbps(Millions of bits, megabits)

MF (Medium Frequency) --- In the electromagnetic spectrum, frequencies from 300 kHz to 3000 kHz. (FTC-STD-1037, p. M-8)

MSC (Mobile-service Switching Center) --- central office and/or central switching office of cellular carriers). MSCs connect smaller radio Coverage Zones (CZs) into a single Area of Influence (AI)

MSDSL (Multi-rate Symmetric Digital Subscriber Line) --- single wire pair symmetric DSL.

NAP (Network Access Point) --- Internet term for major carrier interconnection node on Internet backbone. These nodes, or points, serve to seamlessly interconnect all Internet access providers. Four NAPs were established during the NSFnet years (New York, Washington D.C., San Francisco, and Chicago). Typically, traceroute results can be obtained by customers to see the specific path an Internet "call" or "packet" takes from server to audience.

PCS (Personal Communications Systems) --- use frequency reuse technology in the 1900 MHz frequency bands. FCC "common carrier". Spectral licenses auctioned by FCC. PCS phones allow one and two-way paging, messaging, and voice calls. Fax and video delivery are possible as is some level of location monitoring (911 capability) (Harte, *et al.*) In glossary Harte *et al.* (1997) give three definitions. "1) Any type of wireless technology, 2) A wireless system operating on the North American 1.9 GHz band, in distinction with a system operating on the 800 MHz "cellular" band, 3) PCS-1900 technology in distinction to other access technologies." [Harte, *et al*,1997, p. 404]

PICC (presubscribed interexchange carrier charge) --- an FCC mandated flat per-line charge on presubscribed IXCs. This supplants the traffic-sensitive carrier line charge (CCLC). Capped at $0.53 per line per month for primary residential and single-business lines, this ceiling is slated to increase by $0.50 per year until it equals the monthly per-line common line revenues and residential charge revenues permitted ... less the maximum SLC charge allowed under our rules." (FCC 97-368, p.3) The charge is for a limited period (going) to the recovery of common line costs that incumbent LECs incur to serve single-line customers." (FCC 97-368, p.12) ILEC recovers non-traffic sensitive common line costs not recovered through SLCs.

POTS (Plain Old Telephone Service). Acronym meant to apply to analog telephone lines, especially residential single line service without enhanced telecommunications services such as call waiting, caller ID, etc.

RJ11 --- voice modular jack and coupler.

RJ45 --- data modular jack.

SCC (Specialized Common Carrier) --- During the 1970's, companies that were allowed by the FCC to transmit communications over long distances or within local areas to other subscribers of the SCC only and not to all telephone users via the PSTN.

separations rules --- regulatory terminology for the criteria under which jurisdiction is assigned for communications under multiple jurisdictions. For example, some telecommunications jurisdiction for interstate long distance calls from Florida to Georgia is given to Florida's PSC, some to Georgia's state agencies, and other to the FCC.

SHF (Super High Frequency) --- In the electromagnetic spectrum, 3 GHz to 30 GHz. [FTC-STD-1037, p. E-20, graphic]

SF (super Frame) ---- One kind of framing used with T-1 carriers.

SLC (1) (Schools and Libraries Corporation) --- source of funding for e-rate program under which Internet connection (or data networking) costs of certain public and private schools, libraries, and other institutions are partially paid from the Universal Service Fund.

SLC (2) (Subscriber Line Charge) --- an FCC-mandated fee of up to $3.50 (FCC 97-316, p.1) per month per primary line "collected by your local telephone company to defray part of the costs of providing telephone service. The subscriber line charge covers the costs that can be attributed to placing telephone calls across state lines." (FCC 97-316, p.14) See also PICC and CCLC.

TCA (Telecommunications Act of 1996) --- Public Law 104-104, which amended the 1934 Communications Act.

Throughput (effective and theoretical) --- Throughput is an end-to-end measure that can be expressed as "pure throughput", a theoretical capacity as in maximum attainable bps, or as an observed "throughput rate" rate in bps at time t, where bps_t is an actual time series observation. [Sheldon, 1998, p. 972] Both pure throughput and the throughput rate (also called effective throughput) differ from bandwidth because they are end-to-end measures of the rate at which *user* information (not counting retransmission of errors or transmission of overhead) is processed *and* transmitted. Pure throughput is similar to bandwidth in that it is a capacity, but it is an end-to-end capacity, rather than the capacity of an access line or transport link. For example, compression of voice or data files improves throughput but does not change bandwidth or the second characteristic, data rate.

traditional telephony --- very generally, basic single and multi-line local and long-distance telephone service.

UDSL (Universal Splitterless Digital Subscriber Line) --- Asymmetric, splitterless form of DSL.

URL (Uniform Resource Locator) --- web address based on a domain name needed to establish a WWW home page. For example, www.fred.ifas.ufl.edu is an example of a domain name.

UTP (Unshielded Twisted Pair) or (Unscreened Twisted Pair) --- Copper wiring, three or four twisted pair with RJ45 connectors often used within 100 m of a wiring closet for data (LAN) wiring. Lowest category of such wiring is category 3 (up to 16 MHz, a bit rate of up to 51.84 Mbps) typically used for Ethernet and token ring. Category 5 wiring is specified up to 100 MHz (bit rate of up to 155.52 Mbps). Main difference between categories 3 and 5 is in crosstalk and attenuation performance. [Adams, 1997, pp.78-92] Most existing telephone wiring is sub category 3.

VHF (Very High Frequency) --- In the electromagnetic spectrum, frequencies from 30 MHz to 300 MHz. (GSA, FED-STD-1037C, p. V-1)

VLF (Very Low Frequency) --- In the electromagnetic spectrum, frequencies from 3 kHz to 30 kHz. (GSA, FED-STD-1037C, p. V-1)

Y2K (Year 2000) --- Typically used in connection with the "Year 2000 bug" where certain computer hardware and software will be unable to handle the date change from December 31, 1999 to January 1, 2000.

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